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NAVAL POSTGRADUATE SCHOOL

Monterey, California



THESIS

HYDRO-CRISIS IN THE MIDDLE EAST: WATER SCHEMES FOR A THIRSTY REGION

by

Matthew S. Flemming

June 2001

Thesis Advisor:
Second Reader:

Ahmad Ghoreishi
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Lieutenant, United States Navy
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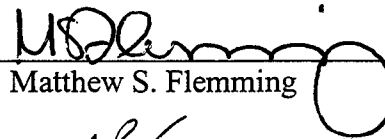
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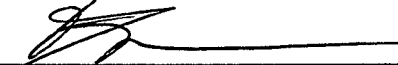
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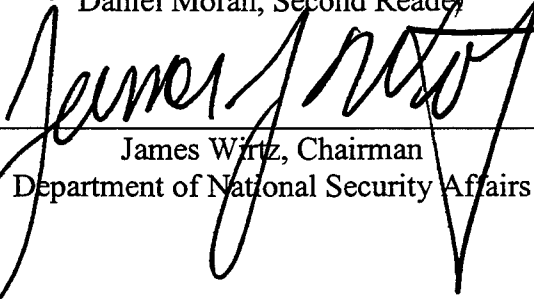
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ABSTRACT

In the Middle East, water is becoming a far more valuable natural resource than oil. Access to water has domestic and regional economic, political, and security implications for the Middle East. Water is likely to be the issue that sparks the next conflict in the Middle East. This thesis describes the impact of rapid population growth and urbanization, industrialization and pollution, and "self-sufficiency" agricultural policies on the water resources of the Middle East. Current capacities of water renewal and water production are not likely to be capable of supporting the future growth of the Middle East without intense planning and management. Five regions of the Middle East are currently feeling the effects of water scarcity: the Arabian Peninsula, the Euphrates-Tigris Basin, the Jordan Basin, the Maghreb, and the Nile Basin. Information is also provided about the Arabian Peninsula, particularly Saudi Arabia. Various schemes to obtain additional water resources are explored including Turkey's proposed "Peace Pipeline," which could supply water from Turkey to the countries of the Levant and the Arabian Peninsula. "Virtual Water" also is explored as a source of water for the Middle East.

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EXECUTIVE SUMMARY

In the Middle East, water is becoming a more valuable resource than oil. Access to fresh water has strategic security implications for the states of the region. Water scarcity is likely to be the spark that ignites the next conflict in the Middle East.

Various factors push water scarcity into the crisis arena. Among these factors are rapid population growth and urbanization, industrialization and pollution, and agricultural policy. Current capacities of water use have placed strains on renewable supplies of water. This situation will only become worse in the future.

Five regions, largely centered on river basins, are explored in this thesis. The Arabian Peninsula is explored in more detail than the other regions, with Saudi Arabia being of particular interest. The other regions explored are the Euphrates-Tigris Basin, the Jordan Basin, the Maghreb, and the Nile Basin.

Various schemes are in use or are proposed to resolve the water crisis. Desalination is the most heavily used method. Other schemes are the Med-Dead and Red-Dead canal systems. There are even plans involving the use of sea-going tankers to deliver water from water-rich countries to water-poor countries. Turkey has proposed a water "peace pipeline" which would deliver water from the Ceyhan and Seyhan Rivers in southern Turkey to the water-poor states in the Levant and the Arabian Peninsula. A very interesting proposal surrounds the use of "virtual water," the creation of additional water resources for other uses by altering water usage and management policies.

The thesis concludes with a summary of the water crisis in the Middle East and some recommendations to resolve the water crisis and potential future conflict over access to water.

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I. THESIS INTRODUCTION

A. THESIS HYPOTHESIS

In the Middle East, water is becoming a more valuable resource than oil. Access to fresh water has economic, political, and security implications. Water scarcity is likely to be the spark that ignites the next conflict in the Middle East. Current capacities of water use are straining renewable supplies of water. This situation will only become worse in the future. The following factors together contribute negatively to water scarcity: rapid population growth; urbanization; pollution; industrialization; and agricultural policy.

There are various methods and proposals to increase water supplies in the Middle East. Desalination is currently the primary means of increasing supplies of water. Israel and Jordan have proposed the Mediterranean-Dead Sea and Red-Dead Sea canal systems. Another proposal is the use of sea-going tankers to provide water to thirsty countries. Turkey has proposed a water "peace pipeline" which would supply water from the Ceyhan and Seyhan Rivers in southern Turkey to the Levant and the Arabian Peninsula.

This thesis evaluates the effects that the proposed water projects, such as the peace pipeline, would have on the Middle East, particularly the Arabian Peninsula. The costs of building these water projects will be compared with the costs of building other means of water production, such as desalination plants, and other methods of water transport, such as the sea-going tankers and the canal systems. "Virtual water " is explored as another means of increasing water supply.

B. THESIS STRUCTURE AND ORGANIZATION

Chapter II examines not only water scarcity in the Middle East, but also the factors that exacerbate the imbalance between water use and the availability of resources. The factors examined are: the impact of population growth and urbanization; the effects of industrialization and economic expansion; the effects of pollution; and the impact of agricultural policies

Chapter III provides a review of the current water situation throughout the Middle East by briefly examining the impending water crisis in each of the following sub-regions: the Euphrates-Tigris Basin; the Jordan Basin, the Nile Basin; and the Maghreb.

Chapter IV provides a similar study of the water situation in the Arabian Peninsula states along the Persian Gulf. Water supply and water usage data is presented as well as population growth statistics to explore the future of water in the following Gulf States: Bahrain; Kuwait; Oman; Qatar; and the United Arab Emirates.

Chapter V provides the same study for Saudi Arabia, including details of numerous water projects currently conducted in the country.

Chapter VI will examine various water resource technologies including desalinization, canal systems, the use of water bags or water tankers, and the proposed water "peace pipeline." The costs of building the pipeline are evaluated in comparison with costs of building other means of water production and other methods of water transport. Also examined is the concept of "virtual water" as a means of creating water by changing policies of water usage and cooperation in water policy between neighboring states.

Chapter VII provides conclusions and recommendations regarding the impending water crisis in the Middle East.

Appendix A provides data on the renewable fresh water resources and the usage rate of fresh water by the Middle East.

Appendix B provides data on the desalination capacity of Middle East.

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II. WATER SCARCITY IN THE MIDDLE EAST

Already today, water rivals petroleum as the single most contested liquid asset in the region due to a combination of growing demand, increasing scarcity, and sources of supply that are dwindling at an alarming rate.¹

In the mid-1980s, U.S. intelligence services estimated that the Middle East was the likeliest place in the world where war could break out over the sharing of dwindling water supplies.² The Middle East and North Africa (MENA) region represents five percent of the world's population but contains only 0.9 percent of the world's water resources.³ The Arabian Peninsula has the scarcest supplies of water and will soon utilize all available fresh water resources. Appendix A shows the renewable freshwater supplies of the eighteen MENA states discussed in this thesis as well as the freshwater usage of the eighteen states.

Access to freshwater is one of the most important issues within the Middle East and is likely to be the cause of future conflict. Many countries share water resources in the form of common aquifers, which are subject to overuse or pollution. This thesis examines the Nile Basin, Jordan Basin, the Euphrates-Tigris Basin, the Arabian Peninsula, and North Africa. Conflict over access to fresh water is likely to occur in any

¹ Aharon Klieman, "Middle Eastern Water Wars." in *The World and I* 13, no. 12 (Dec. 1998). Available [Online]: <http://proquest.umi.com/pdqweb> ProQuest Direct/Search: "Middle East" and "Water" [4 October 2000].

² Joyce R. Starr, *Water Wars* (August 1995). Available [online] <http://www.ciesin.org/docs/006-304/006-304.html> [8 March 2001]. Originally published in *Foreign Policy* 82 (Spring 1991), 17-36.

³ The World Bank Group, *From Scarcity to Security: Averting a Water Crisis in the Middle East and North Africa*, World Bank Report (1996), 6. Also available [online] <http://www.worldbank.org/html/extdr/offrep/mena/focus/booklet.ara.html>.

of these regions in the near future. Security of water resources and continued access to water will soon become a military and defense mission for these countries.

The regional water crisis is not only a result of physical geography, but also of human demographics, particularly rapid population growth. The strategic importance of water has increased to the point that it has begun to affect relations between the countries of the Middle East. Rapid population growth and urbanization in the region, as well as the transboundary nature of most water resources, heightens competition for scarce water supplies. Three major problems have arisen from this competition over water resources:⁴

- First, the distribution of water in the region creates water-rich and water-poor states. Upstream states, from which rivers originate, can exercise great control over the flow to downstream states that also depend on the water. This control can have a destabilizing effect on relations between neighboring countries. Control and allocation of water resources can result in direct conflict between countries.
- Second, to alleviate the shortage of fresh water supplies, countries will require access to advanced technologies to develop water resources or locate new water sources.
- Third, countries are more likely to engage in conflict over the control of and allocation of water.

Aharon Klieman also foretells the coming water crisis and its potential to destabilize domestic regimes, strain interstate relations, and poison regional peace prospects. In every Middle Eastern country, population growth, rising standards of living, agricultural development, and industrial expansion all contribute to place strains on water supplies.⁵ Water use will soon exceed water availability.

⁴ Geoffrey Kemp and Robert E. Harkavy, *Strategic Geography and the Changing Middle East* (Washington D.C.: Brookings Institution Press, 1997), 103.

⁵ Klieman.

Stephen Kiser similarly identifies a “confluence of variables,” which affect each other and serves to add complexity to any comprehensive water solution.⁶

- Water scarcity is the single greatest cause of the water problem in the Middle East.
- Rapid population growth creates a higher demand on an already scarce resource.
- Rapid economic expansion, development, and urbanization place additional pressures on scarce water resources.
- Technological advances make it easier to find and exploit water.
- Poor water management results in the depletion of internal sources of water, such as groundwater, and the non-exploitation of external sources of water, such as rain.
- Vague water laws whereby upstream riparians have sovereignty over water while the water needs of downstream riparians are a secondary consideration.
- Unequal distribution of water due to the transboundary nature of most water supplies is a source of regional tension.
- Previously existing tensions between countries make cooperation on water issues more unlikely given all the above-mentioned variables.

Mostafa Dolatyar and Tim Gray identify five approaches to the water issue: security, economic, legal, technical, and environmental. Their hypothesis is that water plays a “multifunctional role” in all aspects of human life and interaction with the

⁶ Stephen D. Kiser, *Water: The Hydraulic Parameter of Conflict in the Middle East and North Africa*, INSS Occasional Paper 35 (USAF Academy, CO: USAF Institute of National Security Studies, September 2000), 6.

environment. Water issues must be approached in the context of all of the approaches, not just each one individually.⁷

A. REGIONAL WATER SCARCITY

The World Bank paints a very bleak picture of water availability in the MENA region in its 1996 report on water scarcity:⁸

- Over seventy percent of the earth's surface is covered with water.
- Ninety-seven percent of all water is in the world's oceans as unusable salt water.
- Of the remaining three percent that is freshwater:
 - Eighty-seven percent is locked in ice caps, glaciers, the atmosphere, soil, or deep aquifers.
 - Only about thirteen percent (0.4 percent of all water) is usable.
- Of that, less than one percent is in the Middle East and North Africa.

Ten countries in the MENA region already consume more than 100 percent of their renewable water supplies.⁹ Libya's water use exceeds its annual renewable supply by 400 percent. Egypt, Syria, and Iraq consume more water than can be withdrawn from water supplies internal to the country. Egypt utilizes the Nile River for 95 percent of water consumption, while the Euphrates and Tigris Rivers supply Syria and Iraq with 55

⁷ Mostafa Dolatyar and Tim S. Gray, *Water Politics in the Middle East: A Context for Conflict or Cooperation?* (New York: St. Martin's Press, 2000), 15.

⁸ World Bank, 2.

⁹ Gerard Collins, *Water (Problems in the Middle East) II* (September 1997). Available [online] <http://www.medeia.be/en/index247.htm> [8 March 2001].

and 57 percent of water consumption needs respectively.¹⁰ The Arabian Peninsula states consume water at a rate greater than annually renewable water supply production.

Shortage of water is the root cause of the water problem in the Middle East. Low rates of annual precipitation, population growth, domestic pollution, expanding initiatives in agriculture and industry, and rising standards of living further weigh on the water crisis. As stated previously, the MENA region contains less than one percent of the world's water resources, yet represents five percent of the world's total population. Per capita water availability in the Middle East is the lowest in the world—representing only one-third of Asian levels and fifteen percent of African levels.¹¹

B. IMPACT OF POPULATION GROWTH AND POLLUTION

The current rate Middle East population growth averages three percent annually, a rate that is amongst the highest in the world. The total population of the MENA region is already exceeds 423 million and will likely double by 2025.¹² Water use increases with the rise in population and the current population is already taxing existing water supplies.

Growing populations need more water not only for drinking and sanitation, but also for agriculture and industry. The Islamic Network on Water Resources has calculated that the minimum water requirement for each of the 21 Arab League states is 1,250 cubic meters per person per year—55 cubic meters for personal use and 1,150

¹⁰ Aquastat, *Summary Tables of the Near East Region*. Available online] <http://www.fao.org/waicent/faoinfo/agricult/agl/aglw/aquastat/tables2.htm> [26 March 2001]. Table 6.

¹¹ World Bank Group, 5. Illustration 1.

¹² Ilan Berman and Paul Michael Wihbey, *The New Water Politics of the Middle East*, (1999). Available [online] <http://www.israeleconomy.org/strategic/water.htm> [12 March 2001].

cubic meters for agriculture and industry. In 1985, more than half of the countries could not meet this minimum water requirement. By 2025, only three of the countries are likely to meet this requirement, based on population growth rates and current water supplies.¹³

A population that is growing by three percent annually will place severe strains on sewage treatment capabilities and water supply availability. In an area where water supplies are already critically scarce, domestic pollution of these supplies compounds the problem of scarcity. Domestic pollution contributes to the deterioration of usable sources of water and causes a decline in the quality of the water that is available. Over-depletion and lack of controls on use of existing water resources makes pollution and contamination of rivers, lakes, and groundwater more likely to occur. These degraded conditions caused by water scarcity and population growth increase insecurity and make conflict over water more likely to occur.

C. AGRICULTURAL AND INDUSTRIAL POLICIES

In the Middle East, agriculture accounts for eighty to ninety-five percent of water used—yet only represents an average of six percent of the region's gross domestic product (GDP) and employs no more than twenty percent of the population.¹⁴ While cutting back on agricultural production seems to be the likeliest remedy, to the countries concerned, food self-sufficiency is synonymous with independence. Reliance on imported food is unlikely for Middle Eastern countries that have so recently gained their independence from colonial powers.

¹³ Collins.

Industrial use of water will continue to increase and compete with the agricultural sector for water. Industrial demand for water creates additional problems. While industry contributes more to gross domestic product than agriculture, industrial wastewater is more difficult to treat and can end up polluting rivers and aquifers.

Technology allows greater exploitation of water through the construction of irrigation canals, dams, and deeper wells. This increases water supply capacity and allows for the growth of populations, increased agricultural production, improved sanitation, and improves other areas of life. However, technology can also lead to more water problems. Irrigation canals waste water through inefficient watering, dams create large reservoirs which lead to greater water loss through evaporation, and deeper wells further reduce ground water reserves and can increase the salinity of the water supply.¹⁵

Poorly planned farming and field irrigation is a primary cause of water waste. Unregulated well drilling further exacerbates water misuse, increased salinity, or saltwater intrusion of groundwater supplies. Poorly maintained pipes and other water transportation systems waste additional water. Initiatives for the expansion of agriculture and industry further impact negatively on water availability in the region. Growing populations have forced greater expansion of agricultural production and reduction of arable land.

¹⁴ Ibid.

¹⁵ Kiser, 16.

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III. WATER CRISIS IN THE MIDDLE EAST

As water availability and overall quality declines, crisis zones are emerging along the major rivers in the Middle East and North Africa (MENA) region. These evolving conflicts are manifestations of water's growing role as a strategic and political force. Ewan Anderson identified the Jordan, the Tigris-Euphrates, and the Nile basins, as having strategic and geopolitical importance to countries that rely on water from the basins.¹⁶

The crisis zones in the MENA region are:

- The Tigris and Euphrates River—Turkey, Syria, and Iraq
- The Jordan River—Israel and Jordan
- The Nile River—Egypt, Sudan, and Ethiopia
- The Arabian Peninsula—the Arab states of the Persian Gulf¹⁷
- The Maghreb—Morocco, Algeria, Tunisia, and Libya

A. EUPHRATES-TIGRIS BASIN

In the Euphrates-Tigris Basin, Iraq, Syria, and Turkey (figure 1) have invested in dams for the generation of electricity and irrigation of agricultural lands. Turkey, as the upstream state, has the capability to effectively control the amount of water flowing to Iraq and Syria.¹⁸ Table 1 shows the population and growth rates of Iraq, Syria, and Turkey. Figure 2 provides a more detailed depiction of the Euphrates-Tigris river basin.

¹⁶ Ewan Anderson, "Water: The Next Strategic Resource," in Joyce R. Starr and Daniel C. Stoll, eds., *The Politics of Scarcity: Water in the Middle East*, (Boulder: Westview Press, 1988), 5-7.

¹⁷ Less Yemen.

¹⁸ Kemp and Harkavy, 102.

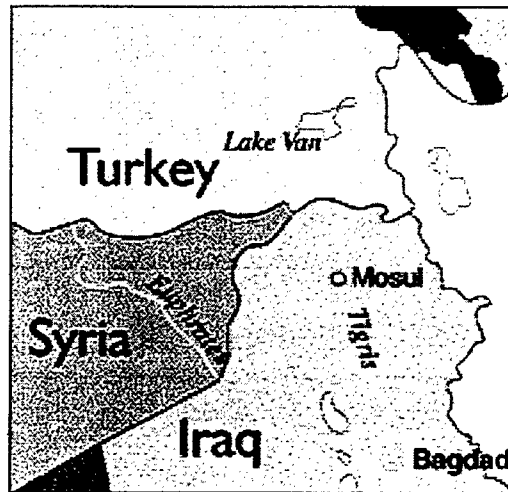


Figure 1. Euphrates and Tigris Riparians.¹⁹

Country	Population (in millions)	Growth Rate (percentage)
Iraq	22.7	2.86
Syria	16.3	2.58
Turkey	65.7	1.27

Table 1. Population and Growth Rate of Euphrates-Tigris Riparians.²⁰

The Euphrates River is 1,700 miles long, originates in Turkey, and flows through Syria to Iraq, where it merges with the Tigris River to become the Shatt-al-Arab River. The river empties into the Persian Gulf. The Shatt-al-Arab estuary is a large marshland, but is navigable for a distance of 450 miles and has many tributaries.

The Tigris River, 1,180 miles long, originates in Turkey and winds southeasterly forming a portion of the northwestern border of Syria and Turkey. Like the Euphrates, the Tigris is partially navigable and has many tributaries.

¹⁹ Source: Ilan Berman and Paul Wihbey.

²⁰ Central Intelligence Agency, *The World Factbook 2000*. Available [online] <http://www.cia.gov/cia/publications/factbook> [Multiple access dates]. All population and growth rate data supplied in this thesis were obtained from the *Factbook*.

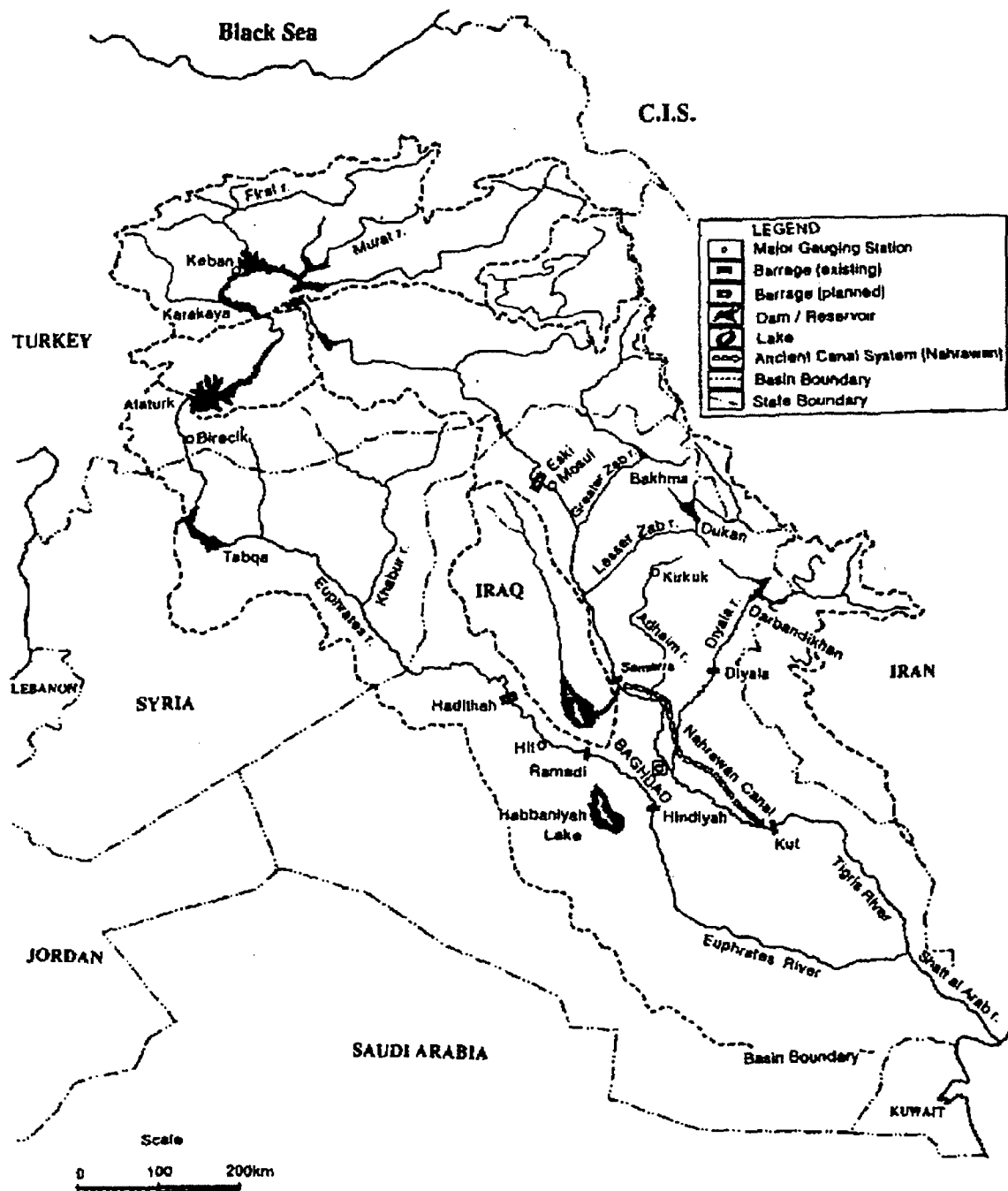


Figure 2. Tigris-Euphrates River Basin.²¹

²¹ Source: Masahiro Murakami, *Managing Water for Peace in the Middle East: Alternative Strategies*, (Tokyo: United Nations University Press, 1995).

1. Iraq

The Euphrates and Tigris Rivers, and the tributary rivers, do not actually drain into the Persian Gulf, but rather supply the southern lakes, swamps, and marshes of Iraq (figure 3) during the tidal cycle. Several dams and reservoirs store floodwaters, the largest of which contains eighty thousand cubic meters, and serveS to generate hydroelectric power. The Shatt-al-Arab drains the remainder of the water to the Persian Gulf. The average total surface water supplied annually is about 84 billion cubic meters.²²



Figure 3. Iraq.²³

Precipitation in the Zagros Mountains serves to supply water for rain-fed agriculture, as does precipitation in the lower elevations. Irrigation is mainly by river

²² Christian E. Gischler, *Water Resources in the Arab Middle East and North Africa* (Cambridge: Middle East and North African Studies Press, 1979), 100.

²³ Source: Central Intelligence Agency.

water in the Mesopotamian plain. In the southern areas of the country, salinity affects fifty to eighty percent of irrigated lands.²⁴

2. Syria

In Syria (figure 4), precipitation is more plentiful in the coastal mountain ranges decreasing eastward and in the lower elevations. In the eastern rangelands, growing human and livestock populations have placed heavy pressure on groundwater supplies through overgrazing and the extension of dry farming.



Figure 4. Syria.²⁵

Renewable groundwater capacity is 1.6 billion cubic meters and is accessed through over 30,000 wells. The largest dam, Tabqa, has a capacity of almost twelve

²⁴ Gischler, 99-100.

²⁵ Source: Central Intelligence Agency.

million cubic meters, while the total of all other smaller dams supplies only slightly more than one million cubic meters.²⁶

3. Turkey

Turkey (figure 5) controls the headwaters of the Tigris and Euphrates Rivers. In 1983, Turkey initiated the \$32 billion Southeast Anatolia Development Project, also known as GAP (*Guneydogu Anadolu Projesi*), a series of 22 irrigation and hydroelectric dams, including the 554-foot high Ataturk Dam (figure 6), along both rivers.²⁷ While the project will supply 24 billion kilowatt-hours of energy and open over 1.5 million hectares of land to irrigated cultivation, low levels of investment in the project could delay completion of the project for fifty years.²⁸ The Southeast Anatolia project has raised concerns in Iraq and Syria over availability of water for their own agricultural and industrial use. At normal flow rates, the Euphrates and Tigris Rivers supply enough water for the needs of all three countries. However drought, combined with the filling of reservoirs, can lead to a lack of adequate water supply in the downstream countries.

Turkey, situated at the headwaters of the Euphrates and the Tigris rivers, can execute extensive control over the flow of these rivers. The GAP project on the Euphrates could escalate disputes over water with Iraq and Syria into regional conflicts. Once completed, GAP may reduce Euphrates water to Syria by forty percent and to Iraq

²⁶ Gischler, 114.

²⁷ Nicole Pope, *When the River Runs Dry?*, 10 October 1999. Available [online] <http://www.msnbc.com/news/319925.asp> [12 March 2001].

²⁸ Starr, *Water Wars*.

by up to eighty percent.²⁹ Turkey's large-scale consolidation efforts are becoming increasingly threatening to Iraq and Syria.



Figure 5. Turkey.³⁰

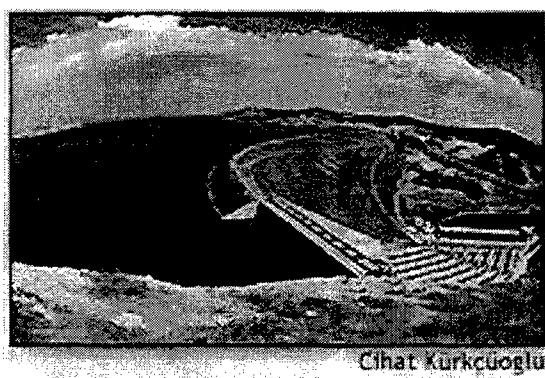


Figure 6. Turkey's Ataturk Dam.³¹

²⁹ Berman and Wihbey.

³⁰ Source: Central Intelligence Agency.

³¹ Source: Nicole Pope.

B. JORDAN BASIN

In the Jordan Basin, Israel and Jordan will face severe water shortages unless they greatly increase their cooperation. Access to water is one of the key issues left unresolved in the ongoing peace process.³² Table 2 shows the population and growth rates of Israel, Jordan, and the West Bank.

Country	Population (in millions)	Growth Rate (percentage)
Israel	5.8	1.67
Jordan	5	3.1
West Bank	2	3.38

Table 2. Population and Growth Rate of Jordan Riparians.³³

The Jordan River is two hundred miles long, originates in Lebanon and Syria, and flows southward through the Sea of Galilee to the end of its course in the Dead Sea. The current of the river is sufficient to support hydroelectric power stations. The water is also used by Israel for the irrigation of agricultural crops in the Negev Desert. The river is shallow and the level often drops during the dry seasons.

1. Israel

Israel's agricultural sector supplies five percent of the gross national product yet utilizes over seventy percent of the country's water resources. Water use in Israel (figure 7) exceeds annual natural replenishment by fifteen to twenty percent with approximately 850 million cubic meters being consumed annually.³⁴ Israel, Jordan, and the West Bank

³² Kemp and Harkavy, 102.

³³ Central Intelligence Agency.

³⁴ Kiser, 10.

face a combined deficit of at least 300 million cubic meters per year upwards to 600 million cubic meters per year.³⁵

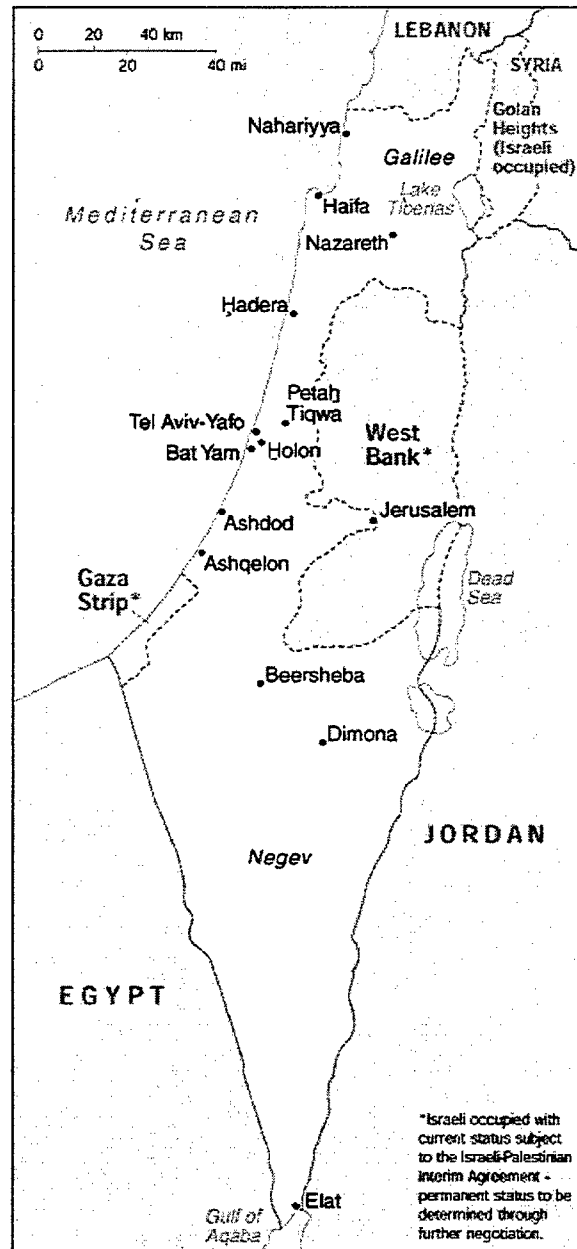


Figure 7. Israel.³⁶

³⁵ Starr, *Water Wars*.

³⁶ Source: Central Intelligence Agency.

2. Jordan

The Jordan River and its tributaries supply 850 thousand cubic meters annually while groundwater supplies are 165 thousand cubic meters annually.³⁷ The Amman Wadi Sir aquifer's water quality is threatened by pollution from household sewage runoff and industrial waste. The aquifer can provide groundwater storage and recharge through injection of storm runoff, treated sewage water, and any other available surplus water.

Jordan (figure 8) is experiencing an escalating water deficit that is expected to reach 250 million cubic meters by 2010.³⁸ Jordan desires to utilize water from the Qa Disi aquifer, which is currently utilized almost exclusively by Saudi Arabia. The aquifer, which lies beneath both countries, may emerge as an issue of conflict.

Figure 9 provides a more detailed depiction of the Jordan River basin.



Figure 8. Jordan.³⁹

³⁷ Gischler, 102.

³⁸ Berman and Wihbey.

³⁹ Source: Central Intelligence Agency.

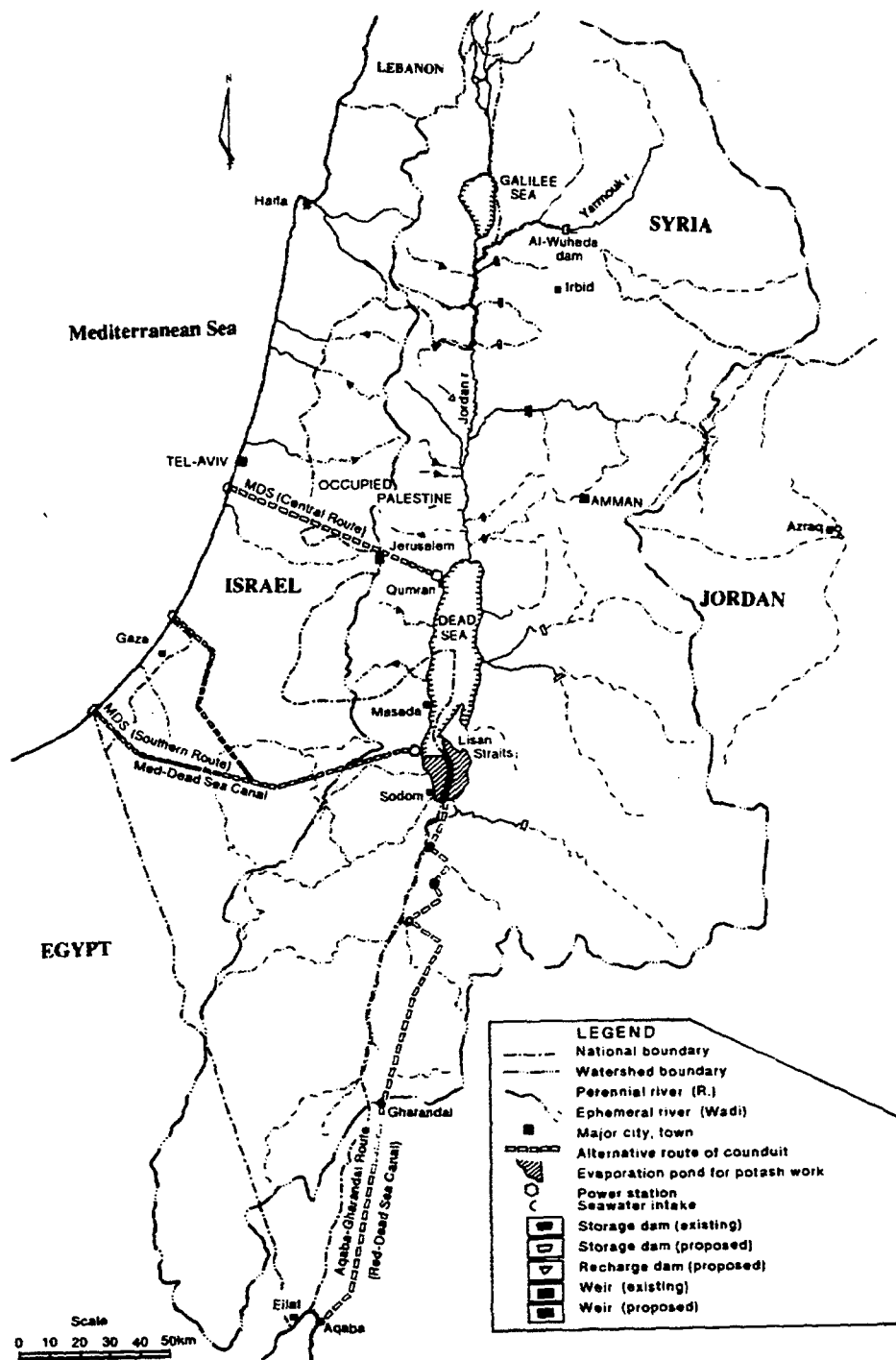


Figure 9. Jordan River Basin.⁴⁰

⁴⁰ Source: Masahiro Murakami.

C. NILE BASIN

Ten countries share the waters of the Nile River Basin, but the main disputes over the water resource has so far involved only three countries, Egypt, Ethiopia, and Sudan (figure 10). Egypt faces the most obvious water crisis, and the situation becomes more severe each year. Its population of 68.5 million is growing by an annual rate of 1.78 percent. Table 3 shows population and growth rates for Egypt, Ethiopia, and Sudan. Egypt is almost completely dependent on the Nile's water and claims that prior usage entitles it to a disproportionate share of the water resource; over ninety-five percent of agricultural production comes from Nile-irrigated land. Egypt needs to expand its agricultural land and reduce saltwater intrusion from the Mediterranean Sea to the Nile delta.⁴¹

Egypt is very concerned about its relationship with Ethiopia since roughly 85 percent of the Nile River's flow in Egypt originates with the Blue Nile. Egypt has frequently warned Ethiopia not to take any steps that would affect the Blue Nile's discharge. Ethiopia has responded on numerous occasions that it reserves sovereign right to use the Blue Nile for the benefit of its own population. Ethiopia has broad plans to develop fifty irrigation and hydroelectric generation projects. As Ethiopia claims a larger share of the Nile headwaters, Egypt will likely experience a slight reduction in Nile water flow.⁴²

⁴¹ Christine Drake, "Water Resource Conflicts in the Middle East," *The World and I* 15, no. 9 (September 2000). Available [Online]: <http://proquest.umi.com/pdqweb> ProQuest Direct/Search: Middle East Water [4 October 2000].

⁴² Ibid.

Egypt is also apprehensive about Sudan. Incapable of expanding its water use at the present, this situation could change in the future. With increased use of Nile waters for agricultural irrigation, Sudan could become the breadbasket of the Middle East. The Nile Waters Agreement of 1929 is one of the most important agreements between the two countries allocating the Nile's waters. The Sudano-Egyptian Agreement of 1959 adjusted the 1929 allocation, reducing Egypt's share.⁴³ Regional economic improvement will require cooperative management of the Nile River and its tributaries. Egypt has protection of its Nile water resources as one of its key strategic objectives.⁴⁴

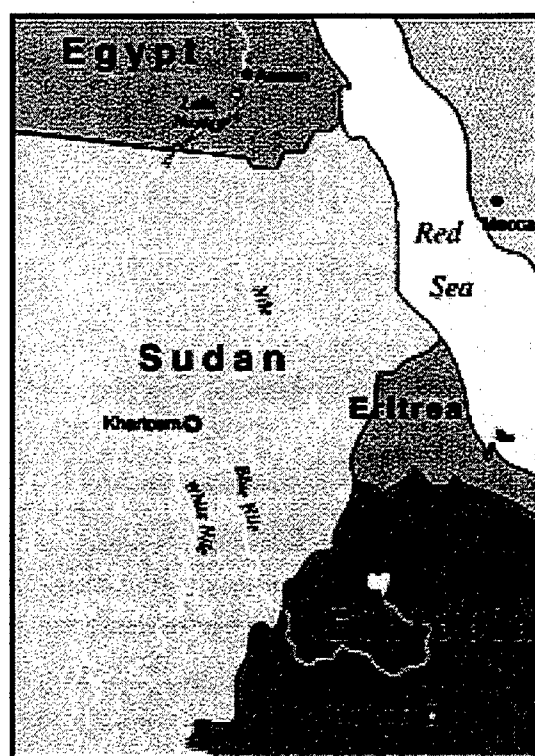


Figure 10. Nile Riparians.⁴⁵

⁴³ Raj Krishna, "The Legal Regime of the Nile River Basin," in *The Politics of Scarcity: Water in the Middle East*, eds., Joyce R. Starr and Daniel C. Stoll (Boulder: Westview Press, 1988), 27.

⁴⁴ Kemp and Harkavy, 102.

⁴⁵ Source: Ilan Berman and Paul Wihbey.

Country	Population (in millions)	Growth Rate (percentage)
Egypt	68.4	1.72
Ethiopia	64.1	2.76
Sudan	35.1	2.84

Table 3. Population and Growth Rate of Nile Riparians.⁴⁶

At a length of 4,160 miles, the Nile is the longest river in the world. One of the major sources of the river is Lake Victoria, which is bordered by Kenya, Tanzania, and Uganda. From Lake Victoria, the Nile flows northward through Uganda, Sudan, and Egypt before emptying into the Mediterranean Sea. From Lake Victoria, the river is known as the Victoria Nile until it enters Lake Albert, after which it is known as the Albert Nile. At the border of Sudan, the river becomes the Bahr al Jabal until it merges with the Bahr al Ghazal to become the White Nile. At Khartoum, the White Nile joins the Blue Nile. From here, the Nile courses towards its distributaries as it empties into the Mediterranean Sea. Numerous dams have been built on the Nile River, the first one was the Aswan Dam built in 1902. Aswan High Dam was completed upstream of its predecessor in 1971. The new dam created Lake Nasser, one of the largest reservoirs in the world. Other dams are the Sennar Dam on the Blue Nile and the Jabal Awliya Dam on the White Nile, both in Sudan.

The Nile River supplies 55.5 million cubic meters of water—this accounts of 86 percent of the water used in Egypt annually. The Nile River's importance to Egypt is not

⁴⁶ Central Intelligence Agency.

The Nile River supplies 55.5 million cubic meters of water—this accounts of 86 percent of the water used in Egypt annually. The Nile River's importance to Egypt is not in its water alone, but also the flow of the river's water. Twenty-eight percent of the country's power is produced from hydroelectric plants on the river. Flood irrigation from the Nile River supplies water for almost all of Egypt's food production. Already Egypt imports fifty percent of its food requirements. Despite these factors, Egypt's water needs will continue to increase. Egypt's population will shortly exceed seventy million, increasing by more than one million per year. Egypt and Sudan are likely to face water deficits within the next ten years. Both currently require about five billion cubic meters per year.⁴⁷

As stated above, the Nile is Egypt's primary source of water for meeting consumption demand—Egypt's reliance on the river's water is absolute. Coupled with the striking seasonal variation in river flow, Egypt suffers from insufficient water during the long, dry summer months. The storage capacity of the Aswan High Dam is essential for coping with periods of low flow levels. Settlement in the Nile basin is intimately associated with the river. In Egypt, most of its population is crowded in a habitable, thirty thousand square kilometer, narrow corridor of arable land along the Nile River and in the Nile Delta.⁴⁸ Moreover, Egypt is the furthest downstream state in the Nile River Basin.

⁴⁷ Starr, *Water Wars*.

⁴⁸ Miriam R. Lowi, "Water and Conflict in the Middle East and South Asia: Are Environmental Issues and Security Issues Linked?" in *Journal of Environment and Development* 8, no. 4 (December 1999). Available [Online] <http://proquest.umi.com/pdqweb> ProQuest Direct/Search: Middle East Water [4 October 2000].

The Nile River is comprised of two major tributaries, the Blue Nile and the White Nile. The two branches of the Nile merge at Khartoum, Sudan, to become the Nile River, which continues its northward course to the Mediterranean Sea through Sudan and Egypt. Fortunately for Egypt and Sudan, the states upstream have shown little interest in exploiting the White Nile and other Nile tributaries. On the other hand, Egypt's position downstream of Ethiopia, on the Blue Nile, is troublesome. The Blue Nile's flow represents over eighty percent of the total discharge of the Nile River. Recently, because of population growth and declining food security, Ethiopia needs to develop the waters of the Blue Nile.⁴⁹

Miriam Lowi uses Egypt to highlight the variety of related features that illustrate the degree to which water scarcity may be considered a national security concern. These features are: the quantity and quality of the water resource relative to present future demand; the nature of water dependency; and, in the case of transboundary rivers, the number of riparian states involved, the nature of relations with the other riparians, and finally, geographic position within the basin. For Egypt, arid climate, high population growth, complete dependence on one transboundary body of water, in downstream position, and the threat of important extractions upstream combine to create the perception that water is a vital security concern. Harmful changes to the water resource would threaten Egypt's welfare and would likely generate a hostile response. Egypt's relative economic, military, and political power makes it unlikely that any of the other states involved would take action to provoke a hostile response.

Figure 11 provides a more detailed depiction of the Nile River basin.

⁴⁹ Ibid.

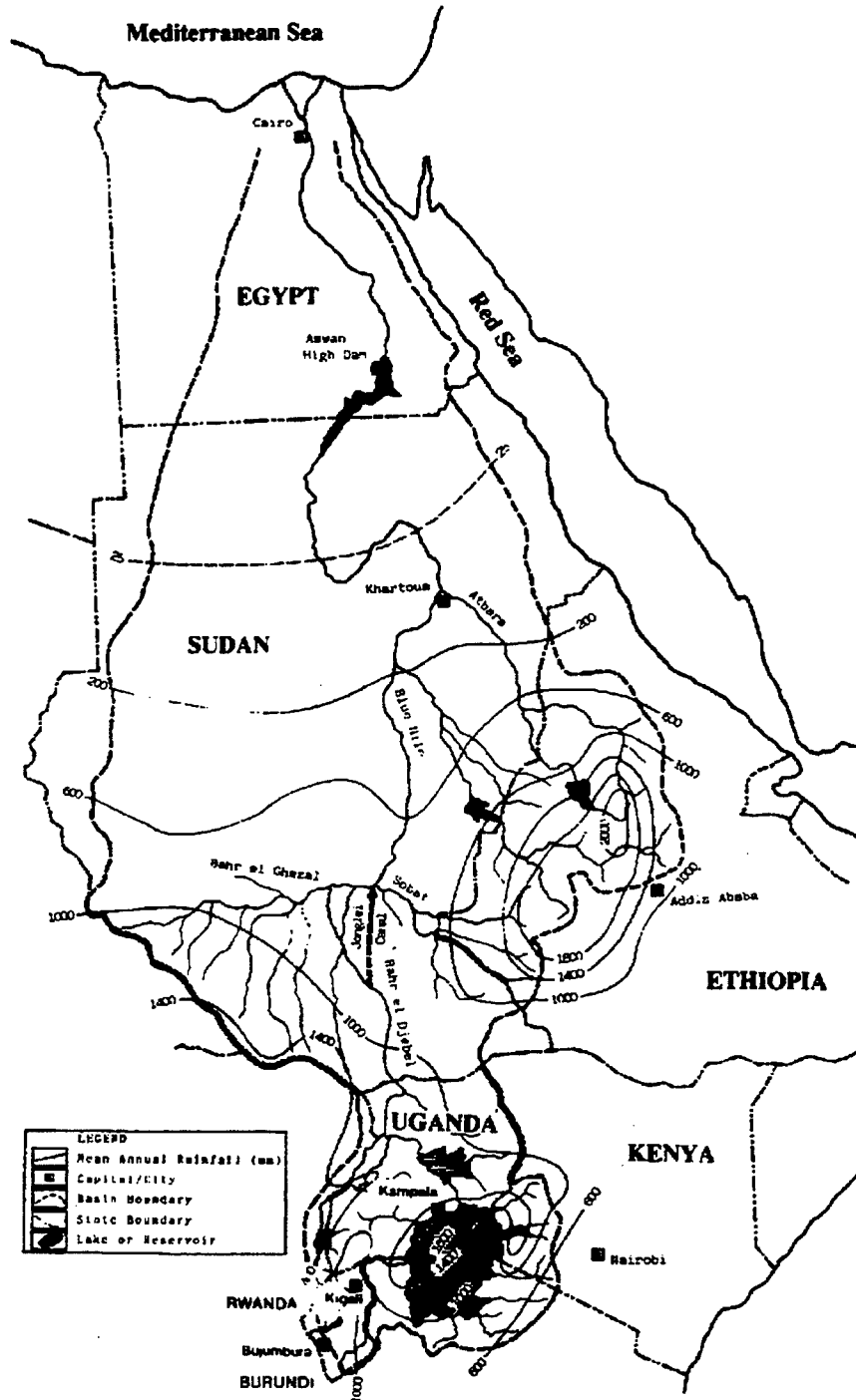


Figure 11. Nile River Basin.⁵⁰

⁵⁰ Source: Masahiro Murakami.

The principal causes for concern in the Nile River Basin are environmental and economic. Lack of written agreements between users of Nile water is largely a result of Egypt's insistence on its overriding needs.⁵¹ Rapid population growth in the states of the Nile River Basin means that demand for water will increase. Existing water resources will have to be used and allocated more efficiently to meet demand. Otherwise, the consumption and development requirements of some states will not be met. The combination of high population growth and a scarce resource is not sustainable and may prove to be highly unstable. Consequently, 25 years from now, when the population has doubled and there is a lack of water resource cooperation, there could be conflict over control of the waters of the Nile River Basin.⁵²

1. Egypt

The Nile River is the whole life of Egypt (figure 12). The country owes its existence to the river, which provides water for agriculture, industry, and domestic use. Nearly the whole population of Egypt resides along the Nile and cultivation is dependent on irrigation from the river.⁵³ Egypt relies on the Nile River for 97 percent of its water needs, despite 95 percent of the discharge originating from upstream states. The Blue Nile, with headwaters in Ethiopia, accounts for 85 percent of the Nile's discharge. Egypt's water use exceeds annual renewable resources within the country.⁵⁴

⁵¹ Natasha Beschoner, *Water and Instability in the Middle East*, Adelphi Paper 273 (London: Brassey's, 1992), 45.

⁵² Lowi.

⁵³ Murakami, 53.

⁵⁴ Kemp and Harkavy, 106.

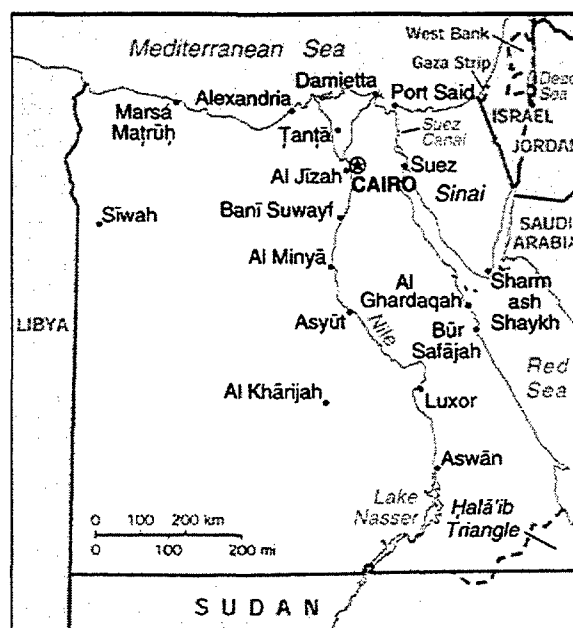


Figure 12. Egypt.⁵⁵

Egypt uses its annual allocation of 55.5 million cubic meters of water from the Nile, and an additional six million cubic meters of Sudan's allocation, due to Sudan's inability to use its full allocation. Groundwater resources are sizeable: 300 million cubic meters in the Nile Delta and 200 million cubic meters in the Nile Valley aquifer. Unfortunately, the groundwater supplies are not economically recoverable and have to be managed closely to prevent a decline in the water table and saltwater intrusion. These two water sources are being used at half the annual renewable rate. Eighty percent of Egypt's water use is for the irrigation of agriculture where water loss is significant due to inefficient water delivery systems.

The Aswan High Dam, completed in 1971, gives Egypt a large measure of control over its national water supply. However, high evaporation rates due to the location and

⁵⁵ Source: Central Intelligence Agency.

climate reduce the efficiency of the dam. Additionally, the hydroelectric production of the dam only accounts for twenty-two percent of total electrical production in Egypt.

Egypt's land reclamation projects, both in the Nile Delta and Valley, and between the delta and the Suez Canal, and in the Sinai, is considered a priority. Only thirty percent of the lands reclaimed become economically productive. Agricultural expansion is largely a response to the country's growing food deficit. Large portions of Egypt's bulk food needs are met by imports despite an increase in domestic food production. Self-sufficiency is exhibited in fruits and vegetables, and Egypt is able to export a portion. While the results of land reclamation and agricultural expansion are questionable, they are clearly a national interest.⁵⁶

2. Ethiopia

Ethiopia's (figure 13) water supply situation is quite favorable relative to its neighbors, Egypt and Sudan. Total surface water supply is 112.6 million cubic meters, of which 55 million cubic meters can be exploited. There are fourteen river basins with a flow rate of over 100 million cubic meters annually across Ethiopia's borders. The problem for Ethiopia is poor distribution of an abundant water resource. One-third of Ethiopia is prone to drought while 540,000 hectares of land is prone to flooding.

Limited irrigation projects have been undertaken as Ethiopia lacks a comprehensive water and agriculture management program. Hydroelectric production is an area of great potential, however the ideal sites for dams are a large distance from

⁵⁶ Beschoner, 47-52.

centers of consumption. Water projects will be a cause of concern for Egypt and Sudan.⁵⁷

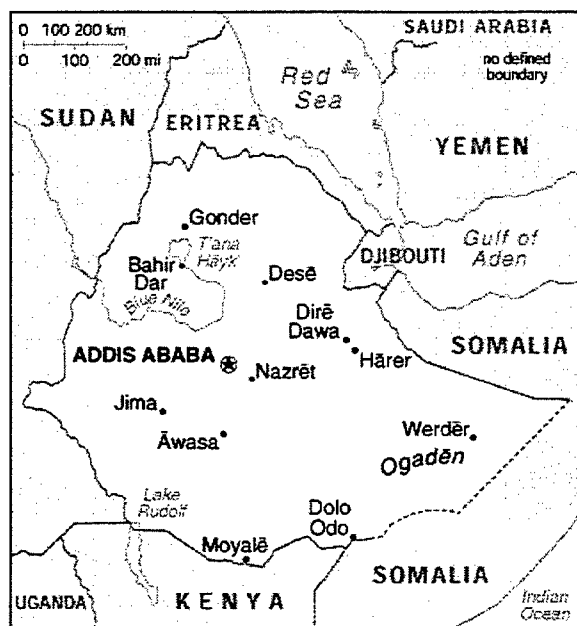


Figure 13. Ethiopia.⁵⁸

3. Sudan

Sudan (figure 14) is allocated 18.5 million cubic meters of Nile water annually by agreement with Egypt, but only uses 12.5 million cubic meters. Over eighty percent of allocated water is used for irrigation of agriculture. The few dams that have been built store eight million cubic meters and satisfy most of Sudan's electricity needs.

Sudan has been developing irrigated agriculture since the 1970's in its plan to become the "breadbasket" of the Middle East. The agricultural schemes have largely failed but great potential still exists provided large investments in infrastructure and proper management are made available. The agriculture sector employs over sixty

⁵⁷ Beschoner, 55-56.

⁵⁸ Source: Central Intelligence Agency.

percent of the population, and accounts for almost forty percent of gross domestic product and 95 percent of exports. However, drought and population displacement have caused widespread food shortages. Misdistribution has also been a factor. Sudan's economic and political situation jeopardizes irrigation development plans.⁵⁹



Figure 14. Sudan.⁶⁰

D. MAGHREB

Not addressed in the literature to the extent of the other areas reviewed above, North Africa is rapidly urbanizing and the population is growing just as quickly. Water resources are quickly becoming strained from overuse and contamination, while erosion and desertification compound the problems of scarcity. Table 4 shows population and growth rates for Algeria, Libya, Morocco, and Tunisia.

⁵⁹ Beschoner, 52-54.

⁶⁰ Source: Central Intelligence Agency.

Country	Population (in millions)	Growth Rate (percentage)
Algeria	31.2	1.74
Libya	5.1	2.42
Morocco	30.1	1.74
Tunisia	9.6	1.17

Table 4. Population and Growth Rate of the Maghreb States.⁶¹

1. Algeria

Algeria's population growth rate, despite ranking amongst the lowest of all African states, is still high enough to pressure development. Fresh water supplies are scarce, but per capita consumption is low. The majority of urban and rural populations have access to unpolluted water. A high priority has been placed on soil conservation as a protection against erosion. Algeria (figure 15) receives precipitation on its coastal zone, high plateaus, and mountain ranges.

The average consumption of renewable groundwater from the northern slope of the Atlas Saharien range exceeds fifty percent with the heaviest usage of groundwater occurring around Algiers, where consumption exceeds eighty percent. Consumption of renewable groundwater from the southern slopes of the Atlas Saharien is at a rate of three million cubic meters per year, three times the annual rate of renewal, however annually renewable groundwater reserves are estimated to be about sixty billion cubic meters.⁶²

⁶¹ Central Intelligence Agency.

⁶² Gischler, 96-97.

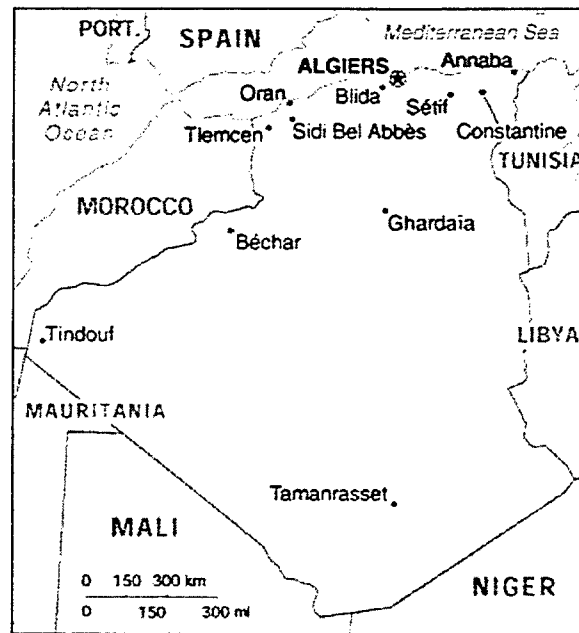


Figure 15. Algeria.⁶³

2. Libya

Libya (figure 16) likely has taken the most interesting and unique approach to water scarcity. There are no permanent streams or rivers in Libya. A network of dams has been built to store runoff from the infrequent rains, and wells have been drilled in many settlements to access underground aquifers. Libya has undertaken a number of irrigation projects to relieve the water shortage, the most interesting of which is the “Great Man-Made River” (figure 17), a vast water pipeline.

In August 1991, Moammar Qaddafi ceremoniously turned a valve that commenced the \$25 billion project to bring water from aquifers in the southern desert to

⁶³ Source: Central Intelligence Agency.

the populations of northern Libya.⁶⁴ The project plans, first laid out in 1979, could take 25 years to complete, but will eventually tap numerous aquifers and transport fresh water to Libyan cities and agricultural areas along the Mediterranean coast. The first phase of the project transports two million cubic meters of water annually through a 1,200-kilometer long pipeline from the southeast aquifer to irrigate the regions of Benghazi and Syrte.⁶⁵



Figure 16. Libya.⁶⁶

⁶⁴ Gary Gardner, "From Oasis to Mirage: The Aquifers that Won't Replenish" in *World Watch* 8, no. 3 (May 1995). Available [online] <http://proquest.umi.com/pdqweb> Search: "water" and "Saudi Arabia" [28 March 2001].

⁶⁵ Collins.

⁶⁶ Source: Central Intelligence Agency.

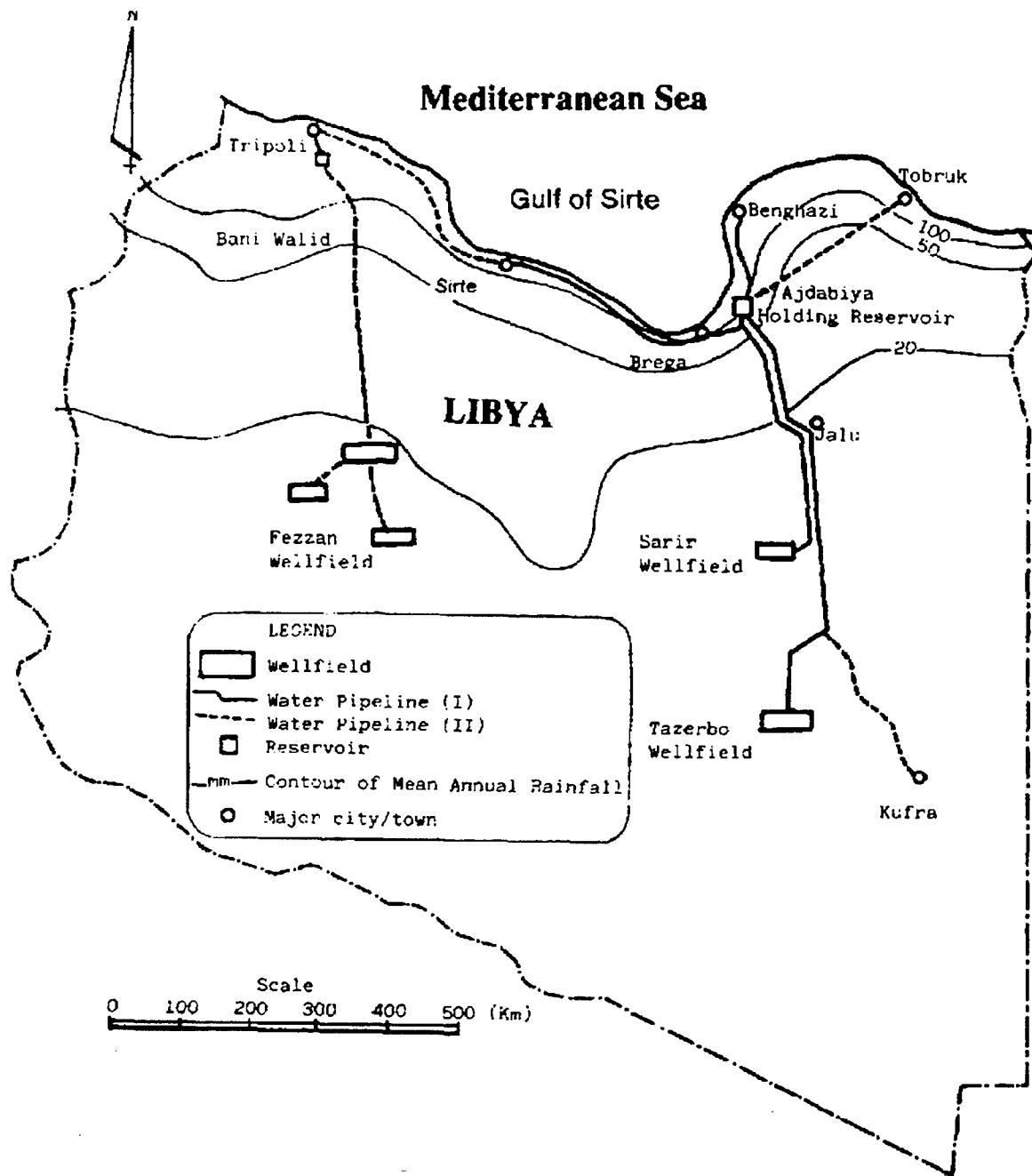


Figure 17. The Great Man-made River Project.⁶⁷

⁶⁷ Source: Masahiro Murakami.

3. Morocco

Morocco (figure 18) uses more than ninety percent of its freshwater supply for agricultural production. Available freshwater for human consumption is limited by pollution from sewage and industrial waste. Periodic droughts contribute to shortages in some areas of the country, and the problem of water scarcity is expected to worsen as Morocco's population continues to grow. Morocco has made serious efforts at water resource allocation and sanitation improvement, but faces a water supply that will decline as the population grows. Storage reservoirs to catch discharged floodwater from rains have a total capacity of over seven million cubic meters.⁶⁸ Renewable groundwater capacity is almost ten million cubic meters, however less the five million cubic meters is usable due to quality problems.

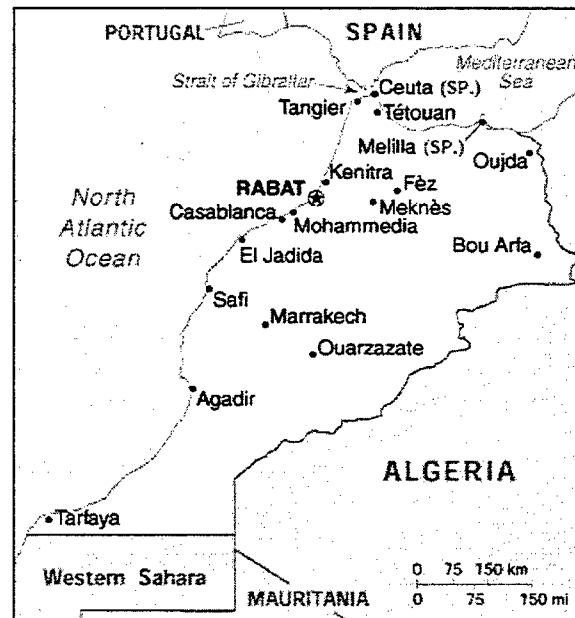


Figure 18. Morocco.⁶⁹

⁶⁸ Gischler, 106-107.

⁶⁹ Source: Central Intelligence Agency.

4. Tunisia

Water scarcity and regular drought are problems for Tunisia (figure19). Tunisia suffers from erosion and desertification. Runoff of untreated sewage is a large contributor to contamination of water supplies.

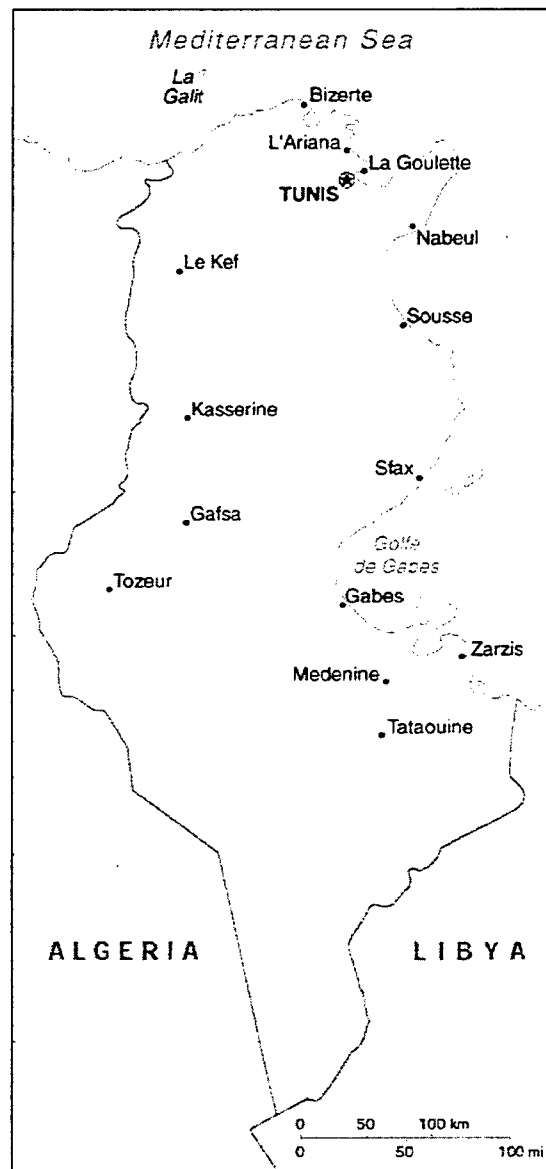


Figure 19. Tunisia.⁷⁰

⁷⁰ Source: Central Intelligence Agency.

Groundwater production is very low, only 1.8 million cubic meters annually. Attempts at catching rain runoff have been largely unsuccessful due to evaporation and silting. Desert encroachment is one of the biggest problems faced by Tunisia. One hundred thousand square kilometers of land is subject to rangeland management through reforestation and sand dune control.⁷¹

⁷¹ Gischler, 115.

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IV. THE ARABIAN PENINSULA

On the Arabian Peninsula (figure 20), water issues expose the vulnerability of the Persian Gulf states. For example, Saudi Arabia requires the operation of twenty-three desalination plants located along its coasts in order to meet half of its fresh water needs.⁷² Gulf states must use petroleum byproducts from oil drilling to distill water while nearby states (Egypt, Iraq, and Turkey) allow water to flow freely into the ocean.

The Arabian Peninsula is an immense, sparsely inhabited desert. Various minerals are produced, including gold, silver, sulfur, and salt, and there are enormous reserves of natural gas and petroleum. However, no permanent streams exist and rainfall is less than seven inches per year. Low rainfall and lack of reliable surface water makes water the most valuable resource on the Peninsula. Desalination has become the primary means of supplying water.

The Persian Gulf countries account for sixty percent of the world's desalination capabilities; Saudi Arabia alone accounts for thirty percent of global production.⁷³ The smaller Gulf States are almost completely dependent upon desalination for their water needs. Desalination plants, expensive to maintain and a critical source of water, can become targets for military or terrorist aggression. During the Iran-Iraq War, both sides targeted dams, desalination plants, and water-conveyance systems.⁷⁴ Water is fundamental to survival on the Arabian Peninsula. Of the ten Middle East and North

⁷² Kemp and Harkavy, 102.

⁷³ Starr, *Water Wars*.

⁷⁴ Kemp and Harkavy, 101.

Africa (MENA) states that already consume over 100 percent of renewable water supplies seven are on the Arabian Peninsula—Bahrain, Kuwait, Oman, Qatar, the United Arab Emirates, Saudi Arabia, and Yemen.⁷⁵

Table 5 shows population and growth rates for the Arabian Peninsula states.

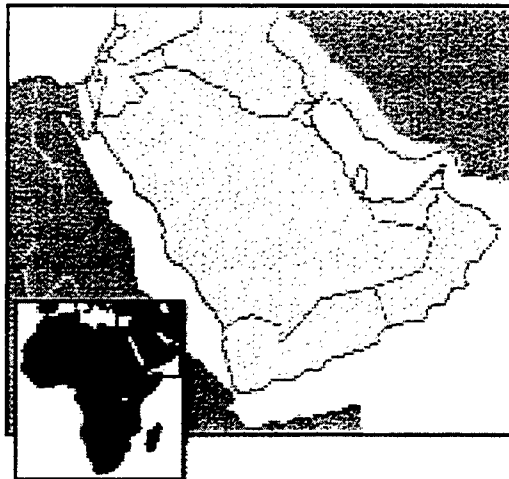


Figure 20. Arabian Peninsula.⁷⁶

Country	Population (in millions)	Growth Rate (percentage)
Bahrain	0.63	1.78
Kuwait	2	3.44
Oman	2.5	3.46
Qatar	0.74	3.35
Saudi Arabia	22	3.28
United Arab Emirates	2.4	1.61

Table 5. Populations and Growth Rate of Arabian Peninsula States.⁷⁷

⁷⁵ Collins.

⁷⁶ Source: MSNBC News

⁷⁷ Central Intelligence Agency.

A. BAHRAIN

Bahrain (figure 21) depends almost entirely on deep aquifers and desalinated water since there is no surface water. Annually renewable groundwater supply is two hundred million cubic meters.⁷⁸ Bahrain's Damman aquifer, which lies under the central portion of the island, has become contaminated by seawater intrusion over the last forty years due to over pumping of the aquifer.⁷⁹

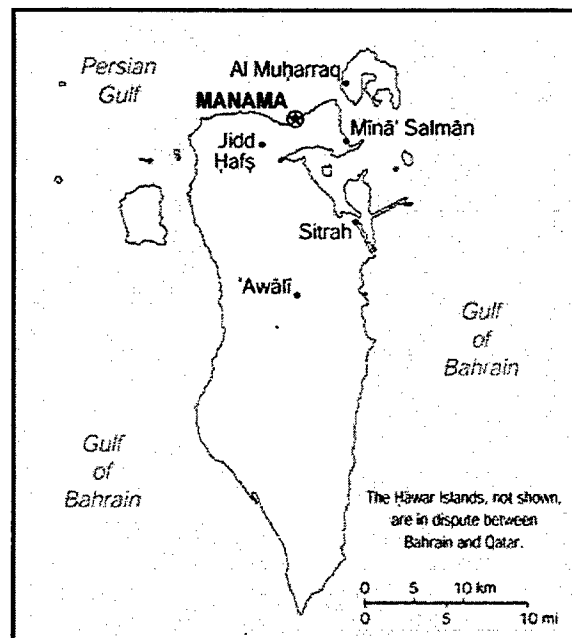


Figure 21. Bahrain.⁸⁰

B. KUWAIT

Deep aquifers supply only thirteen million cubic meters of water; there is no permanent surface water.⁸¹ Before 1950, Kuwait (figure 22) imported water from the

⁷⁸ Gischler, 97.

⁷⁹ Murakami, 103-104.

⁸⁰ Source: Central Intelligence Agency.

⁸¹ Gischler, 102-103.

Shatt-al-Arab by dhow to supplement well water. Kuwait was the first state in the Arabian Peninsula to utilize seawater desalination in conjunction with electrical generation and is one of the first countries to utilize treated sewage effluent for agricultural purposes.⁸² With limited groundwater sources for future exploitation, Kuwait will continue to rely on desalinated water to meet its water needs.



Figure 22. Kuwait.⁸³

C. OMAN

Oman (figure 23) has no permanent lakes or rivers, however *falaj* (man-made channels from underground water sources in the mountains) and springs provide a source of water. The available surface water from the *falaj* is about ten million cubic meters

⁸² Murakami, 114. In addition, treated sewage reused amounted to 97 million cubic meters as of 1988.

⁸³ Source: Central Intelligence Agency.

annually. Exploitable renewable ground water resources amount to 250 million cubic meters annually.⁸⁴



Figure 23. Oman.⁸⁵

D. QATAR

Qatar (figure 24) has extensive groundwater reserves that are recharged by storm water runoff, however this supply is being slowly depleted. The northern aquifer has an estimated reserve capacity of 2.5 billion cubic meters. When added to the numerous depressions and drainage catchments, the total increases to three times that amount. Based on usage figures, the northern aquifer will continue to supply water until around 2010. Desalinated water production first began in 1955 and now provides for most of

⁸⁴ Gischler, 107-108.

⁸⁵ Source: Central Intelligence Agency.

domestic and industrial water use. Recharge of aquifers using desalinated water has been proposed as well as use of treated sewage water for recharge or irrigation of agriculture.⁸⁶

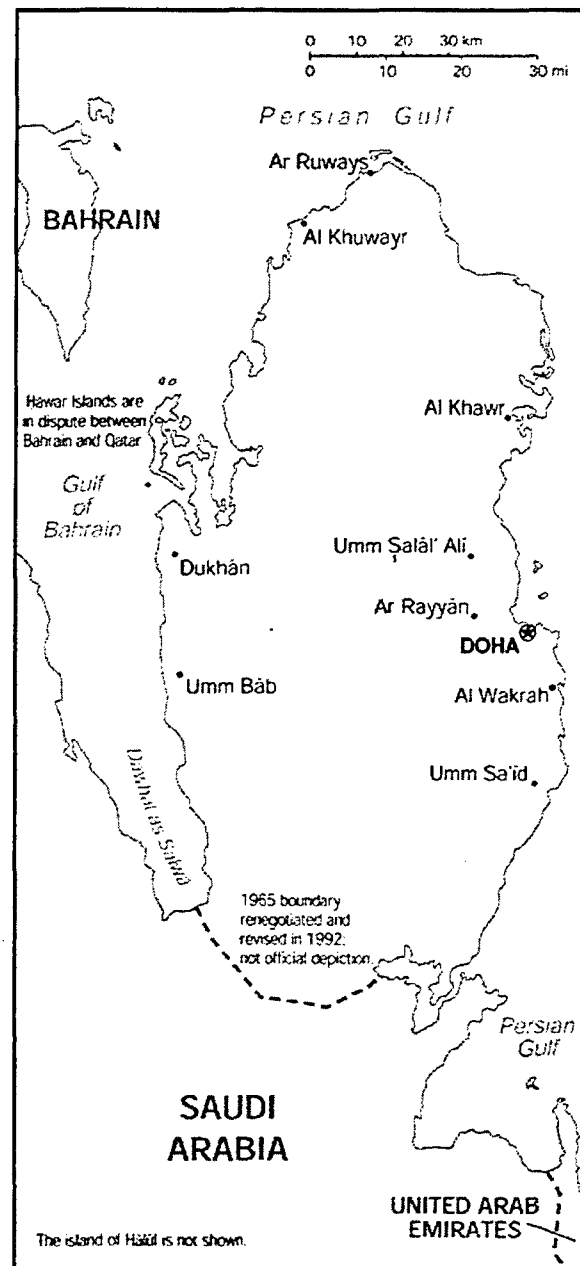


Figure 24. Qatar.⁸⁷

⁸⁶ Gischler, 108-110.

⁸⁷ Source: Central Intelligence Agency.

E. UNITED ARAB EMIRATES

In the United Arab Emirates (figure25) water used for agricultural purposes is ten times that used for domestic and industrial purposes. Ground water supplies amount to 270 million cubic meters annually with surface waters of 160 to 270 million cubic meters available during the year.⁸⁸

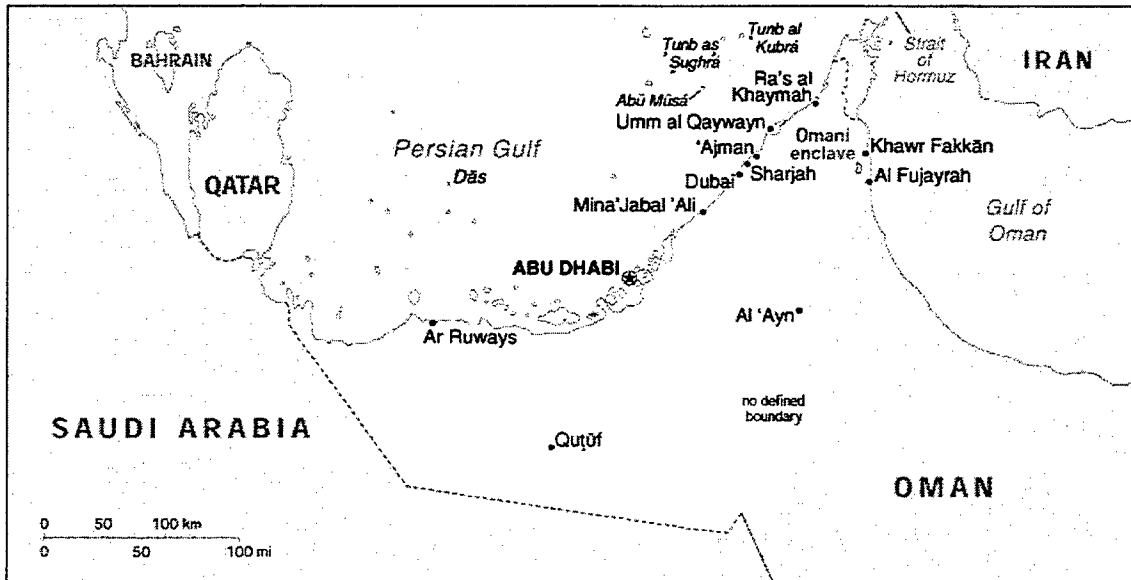


Figure 25. United Arab Emirates.⁸⁹

⁸⁸ Gischler, 116.

⁸⁹ Source: Central Intelligence Agency.

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V. SAUDI ARABIA

Water in Saudi Arabia (figure 26), like oil, is hidden. With little rainfall and high daytime temperatures, water does not exist on the surface for very long. Saudi Arabia's water is found underground. Aquifers provide 88 percent of the country's water, including ninety percent of agricultural irrigation and fifty percent of urban water needs. Agriculture employs 5.5 percent of the labor force and accounts for 8.8 percent of GDP, having risen slightly in the 1990's as petroleum revenues declined.⁹⁰ Water use is estimated to increase fifty percent by 2010.⁹¹



Figure 26. Saudi Arabia.⁹²

⁹⁰ Aquastat, *Saudi Arabia*, (March 1997). Available [online] <http://www.fao.org/waicent/faoinfo/agricult/agl/aglw/aquastat/sauarab.htm> [29 March 2001].

⁹¹ Gardner.

⁹² Source: Central Intelligence Agency.

The Saudi water situation:

- Surface water exists only briefly after infrequent, heavy rains, and riverbeds remain dry most of the year.
- Over 200 dams have been built or planned with a total capacity of about 500 million cubic meters.⁹³
- Largest producer of desalinated water in the world.
- Twenty-seven sewage treatment plants are in operation and half of treated sewage wastewater is reused.⁹⁴
- Groundwater aquifers are estimated to run dry in 25 years.⁹⁵
- Ninety percent of the non-renewable deep-well water is utilized for agricultural purposes.⁹⁶

Desalinated water is often used only for municipal purposes, as it is too saline despite treatment. Treated wastewater is used for irrigation of non-edible crops, landscape irrigation, and industrial cooling. Otherwise, most water used comes from non-renewable aquifer sources and the quality of this water is likely to deteriorate.⁹⁷

Saudi Arabia faces numerous factors—non-renewable water resources, rising consumption, falling supplies, and non-sustainable agriculture—which conspire to strip the country of its future water resources. Saudi wheat production (figure 27) is one area

⁹³ Aquastat, *Saudi Arabia*.

⁹⁴ Ibid.

⁹⁵ Collins.

⁹⁶ Berman and Wihbey.

⁹⁷ Aquastat, *Saudi Arabia*. In 1988, there were 4,667 government wells and 44,080 private wells for multi purpose use. Deterioration in water quality (increased salinity) of some ground water sources results in treatment before being put to municipal use. Coastal areas suffer from seawater infusion.

where much water is wasted. Between 1980 and 1994, 34 billion cubic meters of water was used to produce seventeen million tons of wheat that was exported.⁹⁸ The water used represents seven percent of Saudi Arabia's water reserves or 21 years of non-agricultural water consumption.⁹⁹ Water delivered to the wheat fields for as little as ten cents per cubic meter cost as much as \$1.10 to supply.

Saudi exploitation of the Eastern Province's aquifer reduces water available to Bahrain and Qatar. Disputes have occurred between Saudi Arabia and Jordan over the Qa Disi aquifer. The political tension can produce future conflict over water resources on the Arabian Peninsula—a regional conflict that may engulf Saudi Arabia and its neighbors. Figure 28 depicts the location of groundwater sources on the Arabian Peninsula.

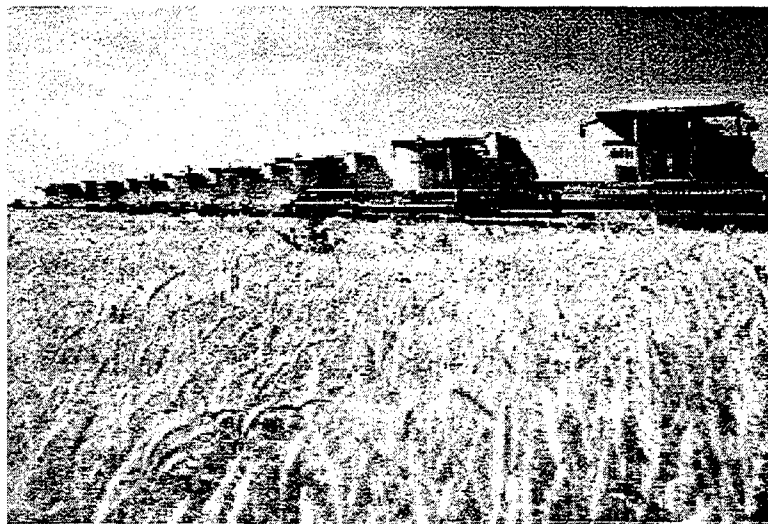


Figure 27. Saudi Wheat Field.¹⁰⁰

⁹⁸ Ibid. In 1992, wheat production was almost 4.1 million tons. National demand for wheat was only 1.2 million tons. Other agricultural exports include vegetables and fruit.

⁹⁹ Gardner.

¹⁰⁰ Source: Saudi Embassy

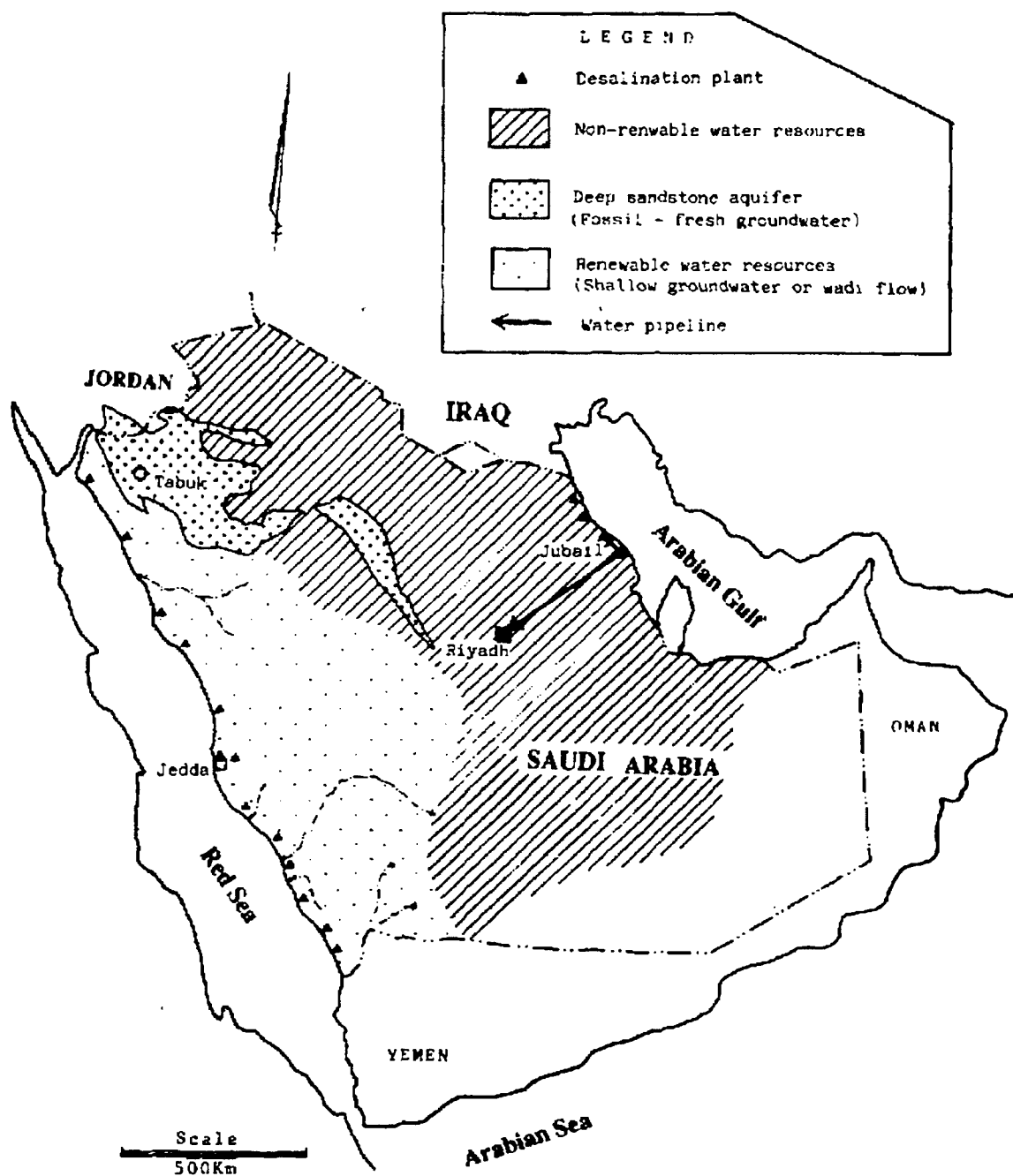


Figure 28. Water Resources of Saudi Arabia.¹⁰¹

¹⁰¹ Source: Masahiro Murakami.

A. SAUDI WATER PROJECTS

Water is an important concern for Saudi Arabia; so much that water is considered a national treasure. Numerous hydrologic studies have been conducted in the pursuit of optimal and prudent use of groundwater resources. Water planning and management is an ongoing effort particularly in areas where wells have been the primary means of supplying water. Maintaining groundwater supplies through regulation and conservation, as well as setting limits to development, are part of this effort. The Saudi Ministry of Agriculture and Water is conducting various water projects. The goal is to create a comprehensive national water plan. Figure 29 depicts a reservoir project.

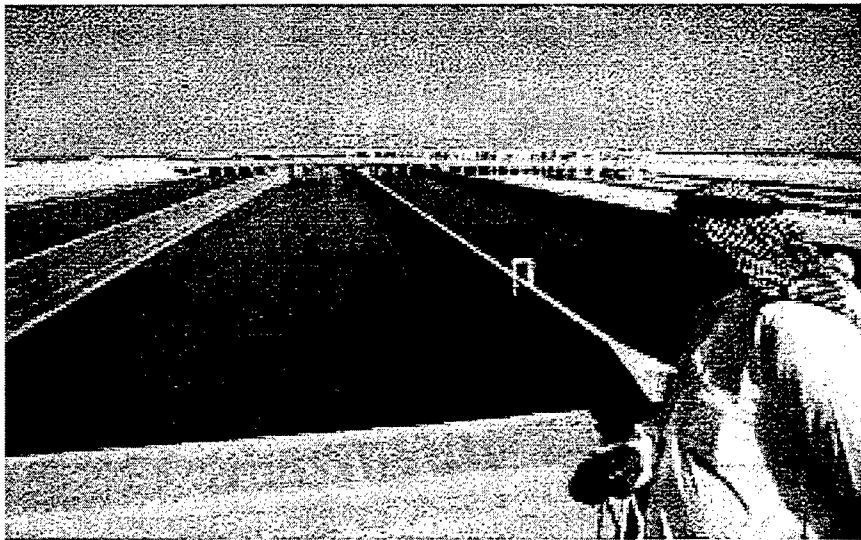


Figure 29. Saudi Water Reservoir.¹⁰²

The largest water development projects include: potable water supply projects, the Riyadh Water Project, comprehensive regional water projects, water projects in other major cities and villages, water towers, and sewage water reuse projects. The water

¹⁰² Source: Saudi Embassy.

projects are also geared towards the creation of an integrated agricultural development plan. These projects include wells, pumping stations, pipelines and piping networks, collection tanks, and dams for the collection of flood waters for drinking, irrigation, and recharge of groundwater resources.¹⁰³

- Potable Water Supply Projects. Water supply projects for cities and rural villages and settlements are prioritized for execution. These projects are mostly well water systems. This project also includes the provision of water by tankers to areas waiting for development.
- Riyadh Water Project. A multi-phased development project was necessary due to the rapid urban development and population growth of the area. Development and treatment of groundwater supplies amounts to the production of over 1.5 million cubic meters per day by numerous desalination plants. The Riyadh Water Project includes the water supply projects in Salboukh, Al Buwaib, Al Wasi, and Jubail. The Jubail project, on the Persian Gulf coast, contributes half of the total water to Riyadh. Water is supplied to Riyadh by extensive networks of wells, pumping stations, pipelines, storage tanks and reservoirs, and treatment plants.
- Regional Water Projects. These projects provide water to large cities or to a number of settlements in a wider area. Water supplies are developed and existing systems are upgraded. These projects aim to decrease the number of wells and reservoirs needed to supply water in a given area, as well as reduce the number of treatment plants required. The thirteen largest projects supply water to over 150 cities, towns, and villages.
- Water Towers. Four water tower projects have been completed and serve as water network pressure compensating tanks. The towers are located in Buraida, Jeddah, Kharj (the tallest at 103 meters tall), and Riyadh (figure 30). The capacity of these towers range from 7,800 to 13,500 cubic meters. Some towers also contain restaurants and vantage points to attract visitors.
- Sewage Water Reuse Project. The purpose of this program is to reduce consumption of groundwater supplies. The treated sewage water is supplied for agricultural and industrial use.

¹⁰³ Ministry of Agriculture and Water, *Water Projects*. Available [online] <http://www.agrwat.gov.sa/minsectors/sectorse/watr0001.htm> [28 March 2001].

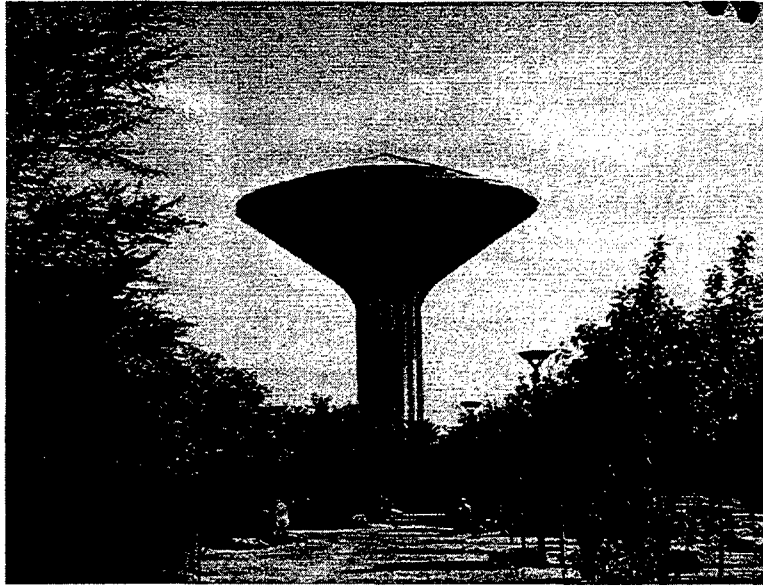


Figure 30. Riyadh Water Tower.¹⁰⁴

¹⁰⁴ Source: Ulf Bagge.

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VI. WATER SCHEMES

Per capita water resources per capita are declining rapidly. Current average annual per capita net water resources in the Middle East and North Africa is about 1,400 cubic meters per person, and this is likely to decline to 700 cubic meters per person by 2025.¹⁰⁵

A. DESALINATION

Desalination is currently the most heavily used method to supply water, especially in the Arab Peninsula. Appendix B shows the world states with the highest desalination capacities. With desalination, freshwater can be produced from brackish water, seawater, or recycled sewage water. Desalination is cheaper than engaging in water disputes or conflict over inadequate water resources, and is cheaper than attempting to divert water over great distances.

Tom Everett-Heath identified 51 desalination projects scheduled for completion between 1999 and 2005. The countries involved are Bahrain, Egypt, Kuwait, Libya, Oman, Qatar, Saudi Arabia, Tunisia, and the United Arab Emirates. The projects range from small plants producing only 500 cubic meters per day to massive plants the size of small cities, such as the Jubail III in Saudi Arabia (figure 31), producing over 725,000 cubic meters per day. Building costs range from \$1.47 million to over \$1 billion.¹⁰⁶

¹⁰⁵ Amikam Nachmani, *A Commodity in Scarcity: The Politics of Water in the Middle East* (1 March 1994). Available [online] <http://www.jcpa.org/jl/hit02.htm> [8 March 2001].

¹⁰⁶ Tom Everett-Heath, "Private Progress," in *Middle East Economic Development* (28 January 2000), 12.

Most of the world's desalination capability (figure 32) resides in the Middle East, particularly along the Persian Gulf and Red Sea coasts. Roughly sixty percent of the world's desalination capacity resides there and many plants serve a dual purpose as power facilities.¹⁰⁷

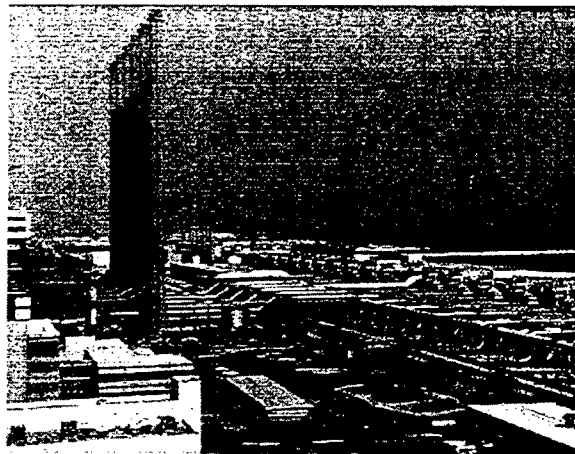


Figure 31. Desalination Plant in Jubail, Saudi Arabia.¹⁰⁸

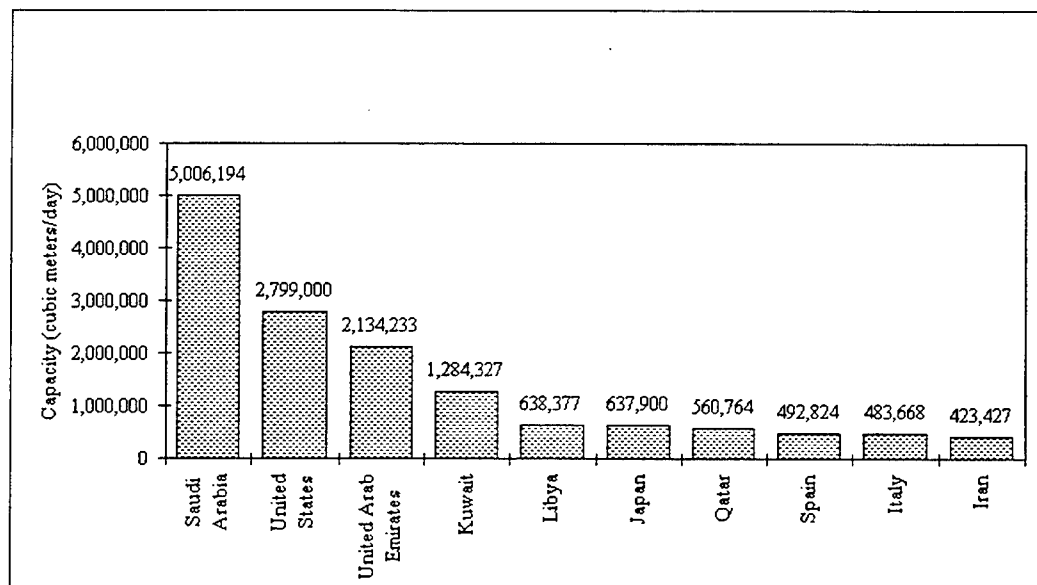


Figure 32. Ten States with the Largest Desalination Capacity.¹⁰⁹

¹⁰⁷ Joyce Shira Starr, *Covenant over Middle Eastern Waters: Key to World Survival*, (New York: Henry Holt and Company, 1995), 54.

¹⁰⁸ Source: Webshots.

B. WATER BAGS/TANKERS

Malaysia and Turkey have proposed two plans for using converted tankers or large towed containers to ship water to the Middle East. Potential buyers are apprehension with these methods due to the ability of other countries to stop water shipments.

1. The Malaysian Plan

The plan proposed by Malaysia involves using a fleet of tankers to annually supply over 39 million tons of water to the Arabian Peninsula at a cost of \$600 million.¹¹⁰ The cost of this water is very expensive at about \$6 per cubic foot. This plan is similar to a 1970s agreement between the Gulf States and the Philippines to transport oil from the Persian Gulf to the Philippines in return for water shipped back in the same tankers.¹¹¹

2. The Turkish Plan

The plan proposed by Turkey involves shipping water in converted oil tankers or by towing large plastic bags from the Manavgat River to Israel. Through this scheme, 150 million cubic meters of water could be extracted annually—it is estimated that this water would cost about fifty cents per cubic meter, about half the cost of desalinated

¹⁰⁹ Pacific Institute, *The World's Water* (6 May 2000). Available [online] www.worldwater.org/waterdata.htm [29 March 2001]. Figure 1.8 Desalination Capacity. Data as of January 1, 1996. Captions removed by author.

¹¹⁰ Collins.

¹¹¹ Amnon Soffer, *Rivers of Fire: The Conflict over Water in the Middle East* (Lanham: Rowman and Littlefield Publishers, 1999), 242.

water.¹¹² Turkey is already using this method to export water to the Turkish enclave in Northern Cyprus.¹¹³ This \$125 million project involves pumps that send river water to a treatment facility and then along a pipeline to two sea terminals from which tankers can be filled with water.¹¹⁴



Figure 33. Manavgat River.¹¹⁵

C. CANALS

Canal systems that would supply water to desalination plants and electricity generation plants have been proposed. Two proposals to ease the shrinking waters of the Dead Sea include the Red-Dead Sea Canal and the Mediterranean-Dead Sea Canal.¹¹⁶ All canal schemes involve the use of canals and tunnels, pumping stations, and power

¹¹² Collins.

¹¹³ Pope.

¹¹⁴ Scott Peterson, *Turkey's Plan for Mideast Peace*, (18 April 2000). Available [online] <http://www.csmonitor.com/durable/2000/04/18/p1s1.htm> [8 March 2001].

¹¹⁵ Source: Scott Peterson.

¹¹⁶ Nachmani.

generation facilities. Each of these projects could cost upwards to \$4 billion to build.

Figure 9 above, shows locations of facilities and proposed canal routes.

- The Red-Dead Plan. Proposed by Jordan in 1981, this plan would pump water from Aqaba, north to Mount Edom, 2,000 feet above the level of the Dead Sea. Over ten billion cubic meters of water per year would rush down to the Dead Sea creating lakes and rivers. The water could drive hydroelectric stations, which in turn would power desalination plants.¹¹⁷
- The Med-Dead Plan. First proposed by Israel in 1980, there are two plan variants: a canal through Gaza to the Dead Sea (southern route) and a canal from Atlit (northern route) that would eventually empty into the northern end of the Dead Sea.¹¹⁸

Given the nature and history of conflict in the Levant fact and each country has its own proposal; it is unlikely that either country will cooperate with the other in building a multi-national water conveyance system.

D. PEACE PIPELINE

In 1986, Prime Minister Turgut Ozal proposed the water "Peace Pipeline," which could supply Turkish water to the Persian Gulf and Levant countries. As proposed, the plan would take water from Turkey's Ceyhan and Seyhan Rivers (figure 34), which empty into the Mediterranean Sea at a rate of 39 million cubic meters per day,¹¹⁹ and transport it southward through two massive pipelines. One pipeline would travel through Syria, Jordan, and Saudi Arabia, supplying water to those states; the other pipeline would supply the Gulf countries of Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates.

¹¹⁷ Kemp and Harkavy, 335.

¹¹⁸ Ibid.

¹¹⁹ Ibid, 337.

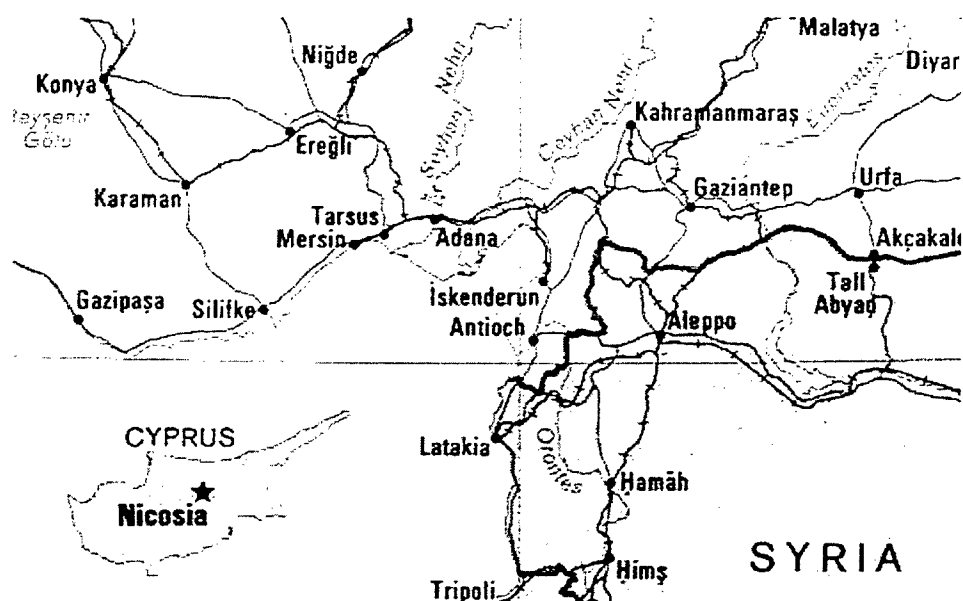


Figure 34. Ceyhan and Seyhan Rivers of Turkey.¹²⁰

Construction of this massive pipeline project would take eight to fifteen years and cost upwards to \$22 billion to build.¹²¹ The “Western” pipeline to the Levant would be over 2,700 kilometers long, cost about \$8.5 billion to build, and supply 3.5 million cubic meters per day to Syria, Jordan, and Saudi Arabia. The “Gulf” pipeline to the Arabian Peninsula would be over 3,800 kilometers long, cost about \$11 billion to build, and supply 2.5 million cubic meters per day to Saudi Arabia and the other Persian Gulf states.¹²² Table 6 shows the distribution capacity of the pipelines. Together, the length of both pipelines and branches would exceed 6,500 kilometers and supply six million

¹²⁰ Source: The Perry-Casteneda Library Map Collection, the University of Texas at Austin. Modified by author.

¹²¹ Gawdat Bahgat, “Stability in the Persian Gulf: The Water Dimension,” in *International Journal of World Peace* 16, no. 1 (March 1999), 51-64. Available [online] <http://proquest.umi.com/pdqweb> Search: “water” and “Middle East” [4 October 2000].

¹²² Kemp and Harkavy, 337.

cubic meters of water daily, about 2.2 billion cubic meters annually¹²³ while only using only one-fourth of the total capacity of the Ceyhan and Seyhan Rivers.¹²⁴

Pipeline	Cubic Meters/Day
<u>Western</u>	
Turkey	300,000
Syria	1,100,000
Jordan	600,000
Saudi Arabia	1,400,000
Total	3,500,000
<u>Eastern</u>	
Kuwait	600,000
Saudi Arabia	800,000
Bahrain	200,000
Qatar	100,000
UAE	600,000
Oman	200,000
Total	2,500,000

Table 6. Distributions of Pipelines.¹²⁵

Funding the Peace Pipeline would require a joint water-sharing agreement between countries using the pipeline. Saudi and Kuwaiti officials did not accept the proposal for political reasons and because desalinated water is cheaper than pipeline

¹²³ Soffer, 239.

¹²⁴ Collins.

¹²⁵ Cem Duna, "Turkey's Peace Pipeline," in *The Politics of Scarcity: Water in the Middle East* eds., Joyce R. Starr and Daniel C. Stoll (Boulder: Westview Press, 1988), 123-124. Modified from Table 7.1 and 7.2. Similar tables are available in Soffer's *Rivers of Fire*, 239, and Dolatyar and Gray's *Water Politics in the Middle East*, 197.

water. Further, a role will be given to Turkey that allows that country to exercise sovereignty and control of waters supplied to the Gulf countries. Arabs would have to rely on Turks for water, and Kuwait would have to rely on water coming from Iraq. A water pipeline that passes through several countries is also vulnerable to attack in a time of conflict. Figure 35 depicts the layout of the various pipelines.

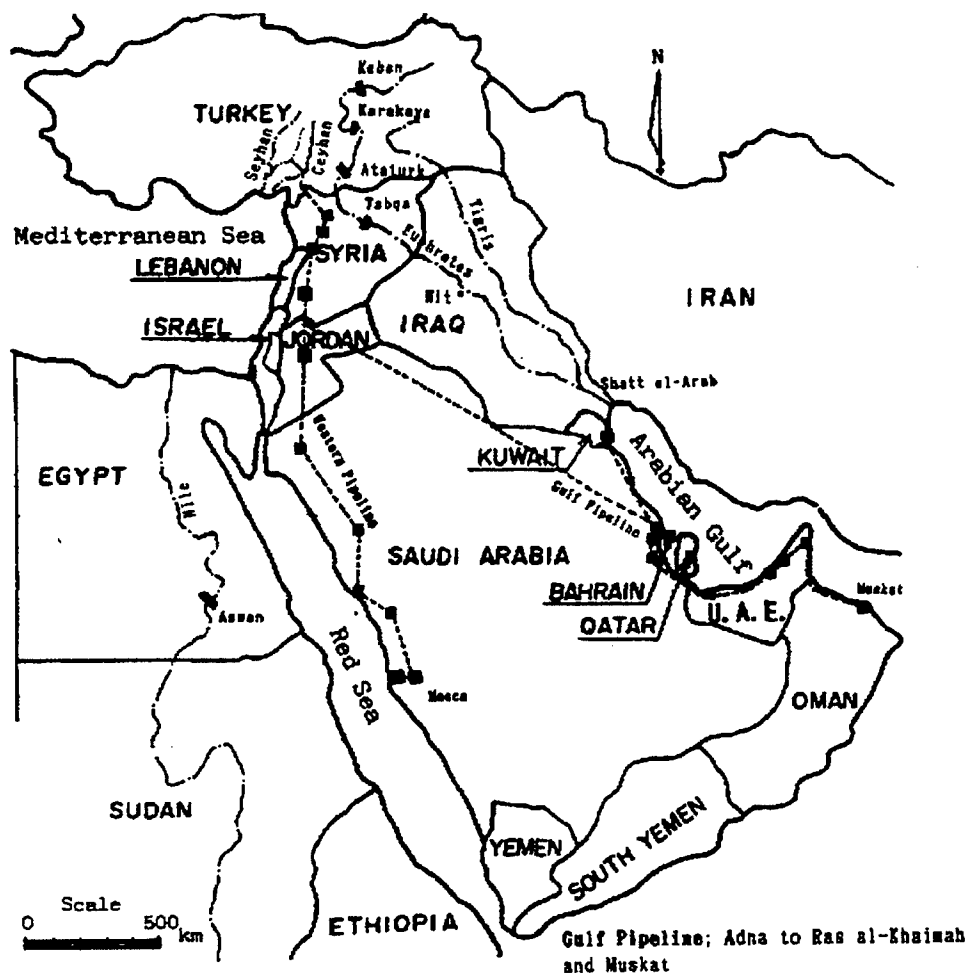
Whatever happens politically in the future, Turkey continues to have a surplus of freshwater while the countries of the Levant and the Arabian Peninsula face an increasing water deficit.¹²⁶ Meanwhile, Turkey's total unused flow of river water to the Mediterranean Sea amounts to sixteen billion cubic meters per year. Jordan and Israel consume 3.2 billion cubic meters of water per year while sources are only renewed at 2.5 billion cubic meters per year.¹²⁷ The Arabian Peninsula states will continue to build their own desalination plants and water projects while they consume more water and population growth continues.

On the other hand, Joyce Starr points out that Turkey is not the water savior of the Middle East.¹²⁸ Turkey does not have an unlimited supply of water. Turkey's present demand for water exceeds fifty percent of exploitable annually renewable water supplies. Growing populations, urbanization, GAP, and agricultural promotion will only serve to place further demands on available water.

¹²⁶ Kemp and Harkavy, 337.

¹²⁷ Peterson.

¹²⁸ Starr, *Covenant over Middle Eastern Waters*, 129.



Western Pipeline: Adna to Mecca

State	City	(m ³ /day)
Turkey		300,000
Syria	Aleppo	300,000
	Hama	100,000
	Homs	100,000
	Damascus	600,000
Jordan	Amman	600,000
Saudi Arabia	Tabuk	100,000
	Medina	300,000
	Yanbu	100,000
	Jeddah	500,000
	Mecca	500,000
Total		3,500,000

Gulf Pipeline: Adna to Ras al-Khaimah and Muskat

State	City	(m ³ /day)
Kuwait		600,000
Saudi Arabia	Jubail	200,000
	Dammam	200,000
	Al-Khobar	200,000
	Hofuf	200,000
Bahrain	Manama	200,000
Qatar	Doha	100,000
	Abu Dhabi	280,000
U. A. E.	Dubai	160,000
	Sharjah/Ajman	120,000
	Umm al-Qaiwain	40,000
	Ras al-Khaimah	
	Fujarah	
Oman	Muscat	200,000
Total		2,500,000

Figure 35. The Peace Pipeline Scheme.¹²⁹

¹²⁹ Source: Masahiro Murakami.

E. COMAPRISON OF SCHEMES

Combining national water systems is the least likely method to resolve the worsening water crisis in the Middle East. Economics and politics form barriers to cooperation in water resource management and allocation. Diversion of water from other countries or reduction in agricultural production is undesirable due to the vulnerability that dependence and lack of self-sufficiency entail. Table 7 shows a comparison of the amount of water supplied and the per unit cost of the various water schemes.

Water Delivery Scheme	Amount of Water Supplied (Million cubic meters per year)	\$ Cost per Cubic Meter
Desalination	50	0.68
Med-Dead Canal	800	0.42
Red-Dead Canal	850	Data not supplied
Used Tankers	200	0.83
New Water Tankers	200	1.12
Large Vinyl Bags	200	0.55
Ceyhan-Seyhan Rivers	200	1.48 avg.

Table 7. Capacity and Cost of Various Water Delivery Schemes.¹³⁰

F. FOR THE FUTURE: *VIRTUAL WATER*

States facing water scarcity must direct their efforts on two levels.

- First, continued improvement in the efficiency of production and allocation of water supplies is essential.
- Second, with the conception of “virtual water,” it is necessary for states to investigate the extent to which they can sustain food production for their population.¹³¹

¹³⁰ Everett-Heath, 10. Data is mostly relevant to the Levant. Desalination costs have been reduced as low as \$0.55 per cubic meter. Red-Dead Canal costs were not provided in table but are likely to be about the same cost as the Med-Dead scheme.

J. Anthony Allan defines *virtual water* as “water required to provide the essential food imports needed by an economy.”¹³² Virtual water can have a direct impact on water supply in countries such as Saudi Arabia, which utilize excessive amounts of water in agricultural production. For example, it requires one thousand tons or one thousand cubic meters of water to produce one ton of grain. A person needs the equivalent of one ton of grain per year. One ton of grain is easier to transport than one thousand cubic meters of water. Therefore, one means by which water deficient countries balance their water budgets is to import food. This virtual water, plus water supplies already present, allows the country meet its water needs.

Efficiency in water allocation and management lead to the effective use of small amounts of water to produce goods and services which are in turn exchanged for those that require large amounts of water to produce. However, most countries would rather be somewhat self-sufficient in food production than depend on imports. As populations grow and urbanization increases throughout the region, the strains on inadequate water resources are growing fast.¹³³

¹³¹ J. Anthony Allan, *Water Security Policies and Global Systems for Water-Scarce Regions*, undated. Available [Online]: [http:// www.worldbank.org/wbi/mdf/mdf1/water.htm](http://www.worldbank.org/wbi/mdf/mdf1/water.htm) [11 October 2000].

¹³² Ibid.

¹³³ Everett-Heath, 8.

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VII. CONCLUSION AND RECOMMENDATIONS

Expanding urbanization, rising birthrates, and aggressive agricultural initiatives are quickly depleting water resources across the Middle East and North Africa (MENA) and greatly affects the geopolitical makeup of the region. Turkey's proposed "Peace Pipeline" to carry water from the Ceyhan and Seyhan River to the Arabian Peninsula failed to progress beyond the planning stage due to regional fears of dependence. Other regional water initiatives, importing water by sea or interstate water allocation, have failed for similar reasons based on discontinuous politics and historical suspicion of neighboring states.

Given the "confluence of variables" that makes a comprehensive water solution so complex, water is likely to play an increasingly larger role in MENA geopolitics. Water-planning issues will likely go hand-in-hand with issues of regional security and stability. The creation of security frameworks is necessary in order to normalize regional tensions over water and foster safety and stability.

Ilan Berman and Paul Wihbey outline numerous steps that countries in the region can take, regionally and domestically, towards creating a structure that will facilitate coherent regional coordination:¹³⁴

- Resolve outstanding disputes over water. Resolution of current water disputes is the first step towards the creation of a regional political alliance over water issues.
- Integrate water into regional strategic cooperation. Integration of water as an element of coordination in the strategic alliances taking shape in the region further moves the region towards strategic water security.

¹³⁴ Berman and Wihbey.

- Modernize current systems of water distribution and processing. The repair of old and damaged water distribution systems and the increase of the efficiency and capacity of existing systems will reduce water waste and raise the amount of water available.
- Consolidate strategic control over current water efforts. Water has strategic value in the Middle East region and countries reliant on vulnerable, expensive desalination plants will have to invest in security. These plants make countries more self-reliant and increase the potential for conflict.
- Implement progressive domestic water initiatives. Success in domestic water initiatives to reduce water usage makes successful water alliances more likely. Regional efforts in research and development should be considered a national security priority.

Through conservation, more benefits can be obtained from each unit of water consumed. Treatment and reuse of wastewater for irrigation or municipal use is one method that has been explored. This treated water can also be used to recharge aquifers. Better delivery and efficient use of water in agricultural irrigation will conserve water through minimizing waste and evaporation. Drip irrigation delivered directly to the roots of crops is another method that is in use.

Steps must be taken to reduce and eliminate pollution of water resources. Sewage treatment plants and national water standards are one means. Another is reduction of pollution from sources such as industrial waste and agricultural pesticides that seep into groundwater supplies or washed into rivers.

Sources of freshwater in the Middle East are scarce to begin with and already heavily stressed by over consumption. Desalination of seawater is currently the most used method for supplying large quantities of water. Desalination plants are expensive and require large amounts of energy to produce water. Both of these factors make desalination an unlikely method for capital-poor, developing, or agriculture-intensive

states, however desalination is probably the most promising answer to the Middle Eastern water crisis. Water scarcity will remain the most likely source of future conflict and cooperation in the Middle East and North Africa (MENA) region.

In 1988, Joyce Starr and Daniel Stoll predicted, "By the year 2000, water—not oil—will be the dominant resource issue in the Middle East."¹³⁵ From the material presented, it is easy to confirm that this is the case today.

Water issues are firmly on the political agenda throughout the region and their significance will grow as the strain on inadequate supplies, and inefficient management and distribution systems, increasingly affect other areas.¹³⁶

¹³⁵ Joyce Starr and Daniel C. Stoll, eds., *The Politics of Scarcity: Water in the Middle East* (Boulder: Westview Press, 1988), 143.

¹³⁶ Everett-Heath, 9.

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APPENDIX A: FRESH WATER SUPPLY

Country	Annual Renewable Water Resources (km ³ /yr)
Algeria	14.3
Bahrain	0.1
Egypt	86.8
Ethiopia	110.0
Iraq	96.4
Israel	2.2
Jordan	0.9
Kuwait	0.0
Libya	0.6
Morocco	30.0
Oman	1.0
Qatar	0.1
Saudi Arabia	2.4
Sudan	154.0
Syria	46.1
Tunisia	4.1
Turkey	200.7
United Arab Emirates	0.2

Table 8. Renewable Freshwater Supply by Country.¹³⁷

¹³⁷ Pacific Institute. Table 1 Total Renewable Freshwater Supply by Country. Modified by author. 1 km³/yr equal 1 million cubic meters per year.

Country	Total Freshwater Withdrawal (km³/yr)
Algeria	4.50
Bahrain	0.24
Egypt	55.10
Ethiopia (and Eritrea)	2.20
Iraq	42.80
Israel	1.70
Jordan	0.98
Kuwait	0.54
Libya	4.60
Morocco	11.05
Oman	1.22
Qatar	0.28
Saudi Arabia	17.02
Sudan	17.80
Syria	14.41
Tunisia	3.08
Turkey	31.60
United Arab Emirates	2.11

Table 9. Freshwater Withdrawal by Country.¹³⁸

¹³⁸ Pacific Institute. Table 2 Freshwater Withdrawal by Country and Sector. Modified by author.

APPENDIX B: DESALINATION CAPACITY

Country	Total Capacity (cubic meters/day)
Saudi Arabia	5,006,194
United Arab Emirates	2,134,233
Kuwait	1,284,327
Libya	638,377
Qatar	560,764
Iraq	324,476
Bahrain	282,955
Algeria	190,837
Oman	180,621
Egypt	102,051
Israel	90,378
Tunisia	47,402
Morocco	19,700
Jordan	7,131
Syria	5,488
Sudan	1,450
Turkey	600

Table 10. Desalination Capacity by Country.¹³⁹

¹³⁹ Pacific Institute. Table 16 Desalination Capacity by Country, January 1, 1996. Table modified by author. Desalination capacity of less than 500 cubic meters per day not included.

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